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Doctorate in Professional Studies

IPH 5320

'AN APPROACH TO INCREASING AWARENESS OF IAQ'

A project submitted to Middlesex University in partial fulfilment of the requirements for the degree of Doctor of Professional Studies

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‘*Can anyone believe it is possible to lay down a barrage of poison on the surface of the earth without making it unfit for all life’.*

‘All this has been risked - for what? Future historians may well be amazed by our distorted sense of proportion’.

(Carson, 2002, p25).

Perfume Word Cloud of Thesis

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Abstract

This project explores the approach to increasing the awareness of indoor air quality using a literature research to evaluate historical context, critiquing combined contaminants, reviewing fragrances, appraising awareness, resources and government policy, both UK and Worldwide. Two surveys were conducted with local authorities and Occupational Health and Safety (OHS) Practitioners in order to explore risk perception and awareness within a real world situation.

The literature research and project activities raised further discussion points regarding the application of risk management, cost effective modelling, impact of body burden, the increase trend of scent marketing, understanding and influencing society risk perception and evaluation of the leadership of IAQ at local and government levels. This project highlights some key recommendations including the requirement to label products, particularly products like perfume who claim brand protection, to enable the consumer to understand the ingredients and make choices about their purchases; Funding for the development of bio-monitoring and multi-pollutant frameworks to build on existing silo contaminant research and create a harmonised and structured approach in understanding psychological and physiological impact interactions from a mixture of pollutants; And the establishment of an IAQ body to lead and engage stakeholders to deliver effective IAQ models. As a legacy of the project, the first accredited IOSH UK IAQ certificate and website was developed, implemented and appraised.

This project is submitted as partial fulfilment of the requirements for the degree of Doctor of Professional Studies with an overall programme plan of 'setting the agenda and raising awareness of IAQ within the UK'.

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Total Word Count: 97,450

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My journey started in 2007 and without steerage from Professor Garelick, I wouldn't have considered my ability to commit and achieve such an accomplishment. I am indebted to Professor Hemda Garelick and Dr Gordon Weller's unfailing time, patience, coaching and guidance throughout the programme; and George Constantinou who provided support and encouragement.

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Despite her absence, I am grateful to my beloved late Nan Teresa whose legacy has provided me with lasting strength, independence and courage.

Finally my husband Lawrence who has tolerated my tears, frustrations, joys and many moments of staring into space with an inability to hold a conversation whilst thinking. He has removed daily distractions and has allowed me to withdraw from the immediate world to immerse into the IAQ arena. When I doubted my ability, he has given me confidence that I have the intelligence to achieve a DProf, particularly reminding me when we have been engrossed in a conversation of 'volatile organic compounds'. He has unwittingly become an expert in the field by reading and reviewing numerous drafts of which I dedicate this paper to him as gratitude.

The personal growth and knowledge I have gained is of unquantifiable value. Upon conclusion of this programme, the completion of my appetite for study will never be suppressed and I will fail to acknowledge what has been done or achieved... but what remains to be done, and so the journey continues...

Chapter 1 - Introduction

1.1 Project Introduction

There are various definitions of Indoor Air Quality (IAQ) and dependent on the context of application, definitions often refer to the condition of the air inside a building affecting an occupant's health.

> '*The totality of attributes of indoor air that affect a person's health and well-being'* (Wesolowski, 1987, p134).

> '*The occurrence of pollutants at concentrations affecting occupant health'* (Brown, 1997, p12).

The World Health Organization does not propose a definition, but does state within their guidance the aim of their advice.

> '*To provide a uniform basis for the protection of public health from adverse effects of indoor exposure to air pollution, and to eliminate or reduce to a minimum exposure to those pollutants that are known or are likely to be hazardous'* (WHO, 2010, p11).

I have not found a concise explanation (Spengler and Samet, 1991) particularly that acknowledges performance and productivity impact. The US Environmental Protection Agency (EPA) offers a broader perspective that is the most similar to my view.

> '*Indoor air quality (IAQ) is a term referring to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants'* (US EPA b, 2012, p1)

Therefore I propose my translation to these discussions as defined by my personal journey through the IAQ arena; I would describe IAQ as the physical, chemical, and biological characteristics of air in the indoor environment and how it relates to the occupant's physical and psychological health, comfort and productivity.

Indoor air quality is not a new concept; however despite our knowledge regarding health concerns, this concept has not been transferred into the workplace from a practical application. Nor has the understanding and awareness for transdisciplinary practitioners, such as OHS professionals, to implement IAQ been explored within the UK. Throughout this project I have discussed the perception of risk from indoor air contaminants and the willingness to improve indoor air quality is contrasted by the lack of policy, direction and information within the public sphere. I have therefore explored the reason for the gap between knowledge and practical application, appraising understanding, resources and government policy.

My DProf programme has been a personal ambition and passion to raise the awareness regarding indoor air quality. The number of chemicals that are manufactured and introduced into our indoor environment is growing, as discussed on page 41. Whilst developing airtight buildings, sealing a building for energy efficiency we have failed to address the balance of the occupancy's health. A perspective articulated by Levin (2006) regarding green and sustainable design buildings that are increasing indoor air quality problems Levin describes the struggle with controlling outdoor pollutants within natural ventilation, and unknown long term understanding of health effects from green materials. Levin (2007) further discusses green materials, referring to Nazaroff and Weschler (2004) discussion on such materials as linoleum (contained in linseed oil) reacting with ozone to produce toxic chemicals.

However a green, sustainable building does not need to be opposing to indoor air quality and organisations such as the UK Green Building Council are forging such relationships across the sectors of architects, designers, landlords to include discussions of healthy buildings (UK GBC, 2013),

Indoor air quality is not just a building structure and materials issue; how occupiers interact with their environment and the activities they conduct within their surroundings has value. Within the growing movement of organic food and drink, individuals can choose whether they wish to reduce chemicals contained in foodstuff they consume; they have limited choice regarding the air that is breathed. Since the smoking ban (HMSO, 2006) social awareness of air quality and how we can affect others with our actions through the unacceptability of second-hand smoke has increased (Oberg, et al., 2011).

When a chemical has a pleasant smell, the perception of risk can be skewed. Until the 19th century natural ingredients were being used to create scents within products, particularly perfumes. In 1921, Chanel launched a jasmine perfume, developed by perfumer Ernest Beaux, who used for the first time aliphatic aldehydes to create an artificial scent, resulting in Chanel No. 5 (Fortineau, 2004). Many of the chemicals in perfumes are the same chemicals that are in cigarette smoke, such as benzene, formaldehyde and toluene (Derudi, et al., 2012; Smith, 2007); merely the influence that fragrances has a pleasant aroma ensures tolerance from exposed occupants; thus creating a challenge with regards to the risk perception and social acceptance of improving indoor air quality. With the increasing use of scent marketing and personal fragrance application, acceptability of such pollutants creates a significant concern for our generation. Accumulated with the lack of research dedicated to the effects of perfume and scent as a contributor to our indoor air environment, I have decided to devote chapters within my thesis for further discussion to highlight my concern.

I have further explored the surrounding agenda of IAQ within this project; including understanding the influence of risk comparisons, cost effectiveness and the impact of body burden (the total amount of a substance in the body) and scent marketing. I have also explored the perception and policy of IAQ from a Global, European and UK perception, understanding how historical research affects our future policy. Concluding with a discussion on how to influence change and reposition IAQ, with recommendations for a national strategy and IAQ leadership.

I have drawn on discussions and steerage from parallel topics, such as environmental management, which tackle similar complexities of social, political and economic impacts when stimulating change.

My DProf project contributes towards knowledge and practice; collectively assembling silo information from literature reviews and surveying of local authorities and OHS practitioners. The data is triangulated for discussions, proposing recommendations to provide a unique focus on current knowledge. My project is also transformative, to ensure it kindles change, I have included project activities that positively contribute towards changing practice, including the development of the first UK's accredited IAQ training certificate and a dedicated website for IAQ resources which creates a legacy upon completion of the project.

The driver of my project is to create knowledge and understanding, to ultimately bring about change in the awareness of IAQ in the UK. Although such conversations are unquantifiable with regards to outcome, it is intended they will stimulate debate and consideration for new research projects for the future to continue the visibility of IAQ.

Failure to address the growing concerns, failure to question our risk perception of IAQ, failure to adopt a strategy for change and failure to bridge the triple helix of academic, commercial and government spheres will result in IAQ evolving as the sleeping giant of the future.

1.2 Chapter Overview

The chapter summaries below are organised thematically and provide an overview of my project.

Chapter 2 – Objectives and Literature Review

Chapter two introduces the aim and objectives of the study. The chapter includes context of the project and parties who may be interested in the findings. It also includes a literature review discussing the history and context of indoor air quality (IAQ), the components of IAQ, including perfume and an appraisal of combined contaminant variables. Following a critical analysis of my literature review, I discuss the significance and shaping of my project that has been influenced by this chapter.

Chapter 3 – Project Design and Methodology

Chapter three provides an overview of the methodologies explored and chosen for my work based learning project. The chapter defines three critical areas of my methodology - survey, action research and methodology considerations, including transferability of literature, change management and ethical reflections.

Chapter 4 – Project Activities

Chapter four provides commentary on the approach to my initial project activities of developing two transformational applications of IAQ into a real world situation. I reflect on my project activities with further knowledge drawn from the findings of the delivered accredited training certificate and feedback from the website portal, which stimulates transformation activities and a discussion of my learning throughout the project.

Chapter 5 – Findings

Chapter five provides a critical analysis of findings from the local authorities' and OHS practitioners' surveys. The chapter also includes feedback from the training certificate implemented and the IAQ website published. Collectively the findings are triangulated and discussions identified from the data compiled within the boundaries of my project dialogue.

Chapter 6 – Discussion

Chapter six explores the repositioning of IAQ in a changing landscape of social science and politics. It also evaluates the challenges to direct a national strategy and leadership within a perceived low risk, tolerable subject matter. The chapter offers a parallel discussion regarding topics which I considered integral to the debate of raising the awareness of IAQ; including an exploration of risk comparison, examining a cost model and debating policy and leadership frameworks; considering further the perceived low risk of perfumes and air quality contaminants within our environments and the body burden effects. I have also reflected on my project regarding the effectiveness and limitation, identifying any contributions to the research of IAQ.

Chapter 7 – Conclusions and Recommendations

Chapter seven proposes key recommendations, including clearer labelling of pollutants, education of IAQ within the triple helix model, the recommendation for further investigation of bio-monitoring and multi-pollutant research; finally considering the value of creating a separate IAQ body to provide a central portal for local government and the public to gain access to information regarding IAQ. Chapter seven concludes with a discussion of my journey through the DProf programme and includes my future aspirations.

Chapter 2 – Objectives and Literature Review

2.1 Chapter Introduction

Chapter two introduces the aim and objectives of the study. The chapter also includes a literature review discussing the history and context of indoor air quality (IAQ), the components of IAQ, including perfume and an appraisal of combined contaminant variables. The chapter discusses the rationale of the development of indoor environmental science and a comprehensive discussion on how our air quality standards have been developed.

Chapter two concludes with a critical analysis of the literature review and provides context to the contribution it has made to influencing and shaping my project.

2.2 Project Aim and Objectives

The title of my project is '*an approach to increasing an awareness of IAQ',* with an overall programme plan of '*setting the agenda and raising awareness of IAQ within the UK*'.

The aim is guided with a research question of *'what resources/discussions are required to raise Occupational Health & Safety (OHS) Practitioner's awareness of IAQ in the UK'.*

The objectives are:

- To conduct a literature review of IAQ to understand UK, European and global positioning, evaluating awareness and appraising future concerns;
- To evaluate current IAQ understanding and risk perception of local authorities and OHS practitioners via two surveys;
- To provide an accessible, free, comprehensive IAQ intranet portal for general (lay) and expert readers;
- To establish a UK indoor air quality OHS industry accredited awareness training programme with a national training body for OHS practitioners and other transdisceplinary professionals;
- To develop recommendations for Government and associated bodies to take ownership for developing IAQ best practice.

The project is not intended to conduct any sampling or analysing of chemical or biological data from indoor air environments, nor contribute to existing information relating to exploring health concerns of occupants, as there is extensive research within these fields.

These objectives have provided a foundation framework for the structure of my project. With the suggestion that we need to be more than competent within IAQ. We, instead, need to be capable of transferring knowledge from silo topics, such as building design, heating, ventilation and air-conditioning (HVAC) installation, air quality monitoring and substance evaluation and evaluate information from established organisations' such as Chartered Institution of Building Services Engineers (CIBSE), Society of Heating and Air-Conditioning Engineers (ASHAE), World Health Organization (WHO), International Society of Indoor Air Quality and Climate (ISIAQ), The Royal Institute of British Architects(RIBA) and the Federation of European Heating, Ventilation and Air-Conditioning Associations (REHVA); to engage autonomous OHS practitioner organisations within the IAQ arena, such as Institution of Occupational Safety and Health (IOSH), Health & Safety Executive (HSE) and British Occupational Hygiene Society (BOHS), to cooperatively develope new learning contexts in a practical setting.

At the start of my DProf programme, I explored various project ideas with the objective of raising the awareness of IAQ. Due to the broad topics within the indoor air quality arena, the diverse stakeholders and the variety of practical applications to highlight the visibility of IAQ, I have focused on how to transfer IAQ literature into an applied environment, interacting with Occupational Health & Safety (OSH) practitioners and local authoritiy regulators..

2.3 Project Outline

Within table 1 below, I have listed the objectives, as discussed on page 20 of my project and correlated with the activities conducted.

Table 1: An outline of my thesis

An outline of my thesis objectives and activities.

Objectives	Project Activity
To conduct a literature review of IAQ to understand UK, European and global positioning, evaluating awareness and appraising future concerns.	**Project Activities:** **Literature Review** • Centrally collate information on indoor air quality from disparate and diverse resources; • Identify key knowledge required by transdisciplinary EHP and OHS practitioners; • Investigate the drivers and barriers for promoting better indoor air quality.
To evaluate current IAQ understanding and risk perception of local authorities and OHS practitioners via two surveys.	**Project Activities:** **EHP's Survey** • Appraise literature review to define the survey questions; • Design EHP questionnaire and evaluate suitable method of delivery; • Pre-test questionnaire and update questionnaire on feedback; • Email 240 EHP surveys questioning knowledge and risk perception of IAQ. **OHS practitioner's survey** • Design online survey for OHS practitioners on the IAQUK website; • Pre-test questionnaire and update questionnaire on feedback; • Distribute link to site via IOSH forum; • Gather data and analyse both surveys separately; • Triangulate with existing literature review to develop key themes; • Following findings define project activities of training and website development.

To provide an accessible, free, comprehensive IAQ internet portal for general (lay) and expert readers.	**Project Activities:** **Development of an IAQ website information portal.** • Appraise literature review to explore current resources and suitable methods for transferability of information; • Identify suitable website content and intended audience; • Design and develop the www.iaquk.org.uk website providing free accessible information; • Evaluate traffic to site, including trending of pages accessed and sources of access; • Review website following survey findings .
To establish a UK indoor air quality OHS industry accredited awareness training programme with a national training body for OHS practitioners and other transdisplinary professionals	**Project Activities:** **Development of an IAQ accredited certificate;** • Appraise literature review to explore transferable data into a training format; • Review IAQ competency requirements; • A review of UK, European and global IAQ training; • Identify audience; • Design an IAQ training certificate; • Engage with a national body to accredit the certificate; • Deliver the certificate and evaluate feedback; • Review the material and delivery and update the certificate; • Integrate training into CPD agenda for continuous training; • Review certificate following survey findings.
To develop recommendations for Government and associated bodies to take ownership for developing IAQ best practice.	**Project Activities:** **Discussion and Recommendations;** • Triangulate findings from surveys, training certificate and website to identify themes and discussion points; • Discuss recommendations; • Reflect on project and DProf Journey; • Discuss strategy for dissemination; • Provide a conclusion.

My thesis is a multi-faceted project, using an action research framework that incorporates literature review, surveys, discussion and tangible outcomes in the form of an accredited IAQ awareness training certificate and website. I used table 1 throughout my project to ensure my activities related directly to my objectives.

Chapter 3 (project design and methodology) and chapter 4 (project activities) provide further details, including a specific section on action research which is woven throughout my thesis. McNiff (1995, p24) discusses the visibility of action research that assists with examining researcher practices and values, ensuring a clear criteria to judge the quality of activities and enabling others to establish a systematic evaluation procedure. Consequently table 1, along with my reflections and discussions contained within my thesis, will ensure my work is available to the critical scrutiny of others. McNiff provides a powerful explanation for choosing action research as a framework:

> *'People do action research as a way of helping them understand how they can influence social change. This commitment is contained in Marx's idea that it is not enough only to understand the world; the intent is to change it for the better'* (McNiff, 1995, p25).

Such clarification has bestowed influential steerage that has motivated me throughout my DProf programme.

2.4 Project Context

This project has been written during an economic slump in the UK, with VAT rising, heavy public sector budget cuts, including the Health & Safety Executive's (HSE) 35% cut (SHP, 2010) and an estimated 490,000 public sector job losses (Guardian, 2010), leading to the highest level of unemployment since 1996 (ONS, 2011).

Within these challenging times, a health and safety review was conducted by Lord Young (DWP, 2010) with recommendations to reduce the burden on small businesses, adopting a common-sense approach, by advocating the abolishment or consolidation of up to half of all existing health and safety regulations. The proposal to reduce the professed 'red tape' of legislation could result in the perception and resources of perceived negligible/low risks with latent health effects, such as indoor air quality (IAQ), to diminish in resources and visibility, compared to high risk activities with immediate impact, such as working at heights, machinery hazards or pedestrian/transport risks.

Neglecting the perception of latent health effects, whereby symptoms can appear many years after exposure, as opposed to prioritizing immediate impact risks, such as falls, can skew the important focus of IAQ risk. Often the lack of data or ability to demonstrate associated costs and contributing factors to health risks can reduce their visibility in society and relegate Government policy decisions, Breyer (1993) discusses how perceived high-risk perception of the public has driven Government policy. Breyer (1993, p19) uses an example of how the Environment Protection Agency consider industrial waste sites as medium to low risk and indoor air quality as medium to high risk. However, the public perception is reverse and therefore more funding and policy decisions will be spent on hazardous waste sites.

Hunter (2003) defined ten common barriers to effective health policy implementation which essentially discussed the complexities of cause and effect, and the multiple intervening links and relationships, such as difficulties in managing/monitoring health risks and the lack of resources to apply effective policy decisions.

To challenge such complexities within a real world research project, I have included a framework for action research within my methodology. Thus ensuring an integrated problem-solving process is considered and extraction of lessons are included to new knowledge through reflections and experience; which I considered as an organic process throughout the project. Consequently ascertaining and understanding the methods of influence, rather than regulation enforcement, as a catalyst for change. Drawing a comparison to environmental self-regulation and compliance, Short and Toffel (2010) ask whether self-regulation is merely a symbolic commitment, they concluded that:

> *'Organisations are more likely to follow through on their commitments to self-regulate when they (and their competitors) are subject to heavy regulatory surveillance and when they adopt self-regulation in the absence of an explicit threat of sanctions' (*Short and Toffel, 2010, p362).

An essential application of my project is the collaboration of my academic understanding of IAQ interfaced with the challenges and perceptions of a commercial environment; working with organisations and individuals to develop a cohesive body of understanding that contributes to the indoor air quality debate. In particular the transfer of embodied knowledge into contextual practices, via training and a website resource, with the intention of influencing key stakeholders for future sustainability of IAQ within an academic and OHS practitioner's sphere to encourage self-regulation and applied practices.

2.5 Stakeholders who may be interested in the research

Reviewing the interaction between organisations, government and my role as an OHS practitioner, I drew parallels to the triple helix model (Etzkowitz and Leydesdorff, 2000) which describes the resulting dynamic and fluctuating interplay between university-industry-government. Historically these roles have defined remits - novelty production (academia), wealth generation (industry), and public control (government) (Etzkowitz. and Ranga, 2010). Etzkowitz and Leydesdorff (2000) propose that although each sphere of activity has a defined role, the overlay of interactions between these functions can co-innovate. Leydesdorff and Meyer (2006) describe the triple helix to the contribution of:

> 'R*ich ecologies": the construction of careful balances between differentiation and integration among the three functions'* (Leydesdorff and Meyer, 2006, p1441).

Etzkowitz and Leydesdorff (2000) are primarily discussing the context of the triple helix model as commercialization of new knowledge, cited such a synergy would provide countries the ability to retain wealth from knowledge and knowledge from wealth. And although this project is not driven by commercializing knowledge; within a work-based project, the dynamics of the relationships, the different drivers for each sphere and the perception of their position is an important consideration. Leydesdorff (2013) suggests the Triple Helix model provides us with an incentive to search for mismatches between the institutional dimensions. As an OHS practitioner who has operated within all of these spheres, I consider my own application in traversing these roles and understanding the different needs of the model, whilst collaborating with identified stakeholders.

Therefore, I have identified a diverse range of stakeholders who may find interest in my project, as listed within table 2.

Table 2: IAQ Stakeholders

A list of UK and international stakeholders who could influence indoor air quality standards.

Government

- World Health Organization - WHO
- Department of Health (Committee on the Medical Effects of Air Pollutants (COMEAP) and bio-monitoring)
- Department of Business Enterprise and Regulatory Reform (BERR) (product)
- The Department for Environment, Food and Rural Affairs (DEFRA) (policy makers for the environment)

Enforcement

- Health & Safety Executive (HSE)
- Environmental Health Practitioners (EHP)
- Local Authorities (health and safety, housing, environment)
- Health protection Agency (HPA)
- Trading Standards

Professional Bodies

- Chartered Institution of Building Services Engineers (CIBSE)
- Society of Heating and Air-Conditioning Engineers (ASHAE)
- International Society of Indoor Air Quality and Climate (ISIAQ)
- UK Indoor Environments Group (UKIEG)
- Indoor Air Quality Association (IAQA)
- The Royal Institute of British Architects(RIBA)
- The Federation of European Heating, Ventilation and Air-Conditioning Associations (REHVA)
- Institution of Occupational Safety and Health (IOSH)
- British Occupational Hygiene Society (BOHS)
- The British Institute of Facilities Management (BIFM)
- Reading University's Intelligent Buildings Laboratory (IBL)
- The Institute of Environment and Health (IEH)
- The Chartered Institute of Environmental Health (CIEH)
- Trade Unions

Commercial

- Architects
- Manufacuturers
- Health & Safety Practitioners
- Occupational Hygienists
- Occupational Health Practitioners
- Heating, Ventilation and Air-Conditioning - HVAC Technicians
- Facilities Practitioners

Other

- Landlords
- Occupiers
- Employers
- Employees
- Consumers
- Colleges
- Universities
- Training organisations

Traditionally universities are seen to provide knowledge, Gibbons et al., (1994) challenged prescribed understanding of knowledge production that existed within research disciplines. Gibbons et al., (1994) referred to different 'actors' engaged in a contextualised problem solving oriented process, thus creating value of knowledge in society, thus extending the use of research to beyond the boundaries of universities and academics alone. As an example, creating a knowledgeable consumer that makes choices about purchasing none-perfumed products. I have specifically selected a broad range of interested parties, as I believe that change is driven from the category of stakeholders listed within table 2. I draw this conclusion from reading environmental literature that discusses sustainability of environment goals and objectives by developing a social community that demands change. Frasier et al., (2006) succinctly describes the advantage by engaging the wider community to drive an agenda:

> '*The formalisation of 'bottom-up' community involvement in environmental management projects has been driven by past failings of 'top-down' approaches'* (Fraiser et al., 2006, p114).

I draw a parallel to Fraser et al., (2006) who discuss the bottom-up approach as a pathway to community empowerment and sustainable environmental management (Fraser et al., 2006, p126). Beer et al., (1990, p68) discussed the advantages of bottom-up (commitment and subject knowledge) and disadvantages (slow and ill-defined direction) of such approach, concluding that effective management incorporates the benefits of top-down as well as bottom-up change efforts while minimizing their disadvantages.

I believe that a participatory process of all Stakeholders is essential to create a push – pull effect, whereby, referring to table 2, the 'Government', 'Enforcement' and 'Professional Bodies' create a push with resources, policy and steerage and the 'Commercial' and 'Other' create a pull for implementation.

The success of such application is understanding the needs of a community and customising the chosen method for engagement; which I explore through this project via surveys understanding the push (Enforcement – local authorities) and pull (Commercial – OHS practitioners)

Furthermore, I considered Lewin (1943) force-field analysis of the driving forces and restraining forces to achieve effective change within IAQ, as discussed on page 192.

In addition to the input of the project, I have also appraised the output and dissemination. Considering a broader readership, I have therefore decided to write my project in lay text, complemented with raw data to allow future debate and to ensure transferability of discussions.

2.6 Literature review

This chapter incorporates a search strategy with the objective to review and critique the literature relating to IAQ. Such activity has enabled me to discuss existing literature, identifying any gaps and assisting with developing my conceptual framework around the methodology. The literature review ultimately shapes my project activities; thus providing necessary unpinning competence and reference that facilitated a realignment of my project objectives, in an action research cycle, to ensure value and credibility in my project.

The literature review encompassed several purposes, firstly it triangulated the topics presented in the search, it also conducted a gap analysis and enabled me to contribute to the wider on-going dialogue about the topic. To provide orientation of the literature, I used a literature map which provided a visual summary of the literature; using composition circles containing a body of literature and how it interacts with other sections of the proposal, as discussed on page 35, figure 1. Thereafter a methodological critical review supported the thematic literature to be applied in a working environment, challenging conceptual frameworks; thus suggesting a wider discussion that embraces practical application of theory and economical cases for implementation IAQ practices. A visual representation presented in a helicopter view of the diverse subject matters provides the opportunity to conceptualise how they interact with each other.

The transfer of such knowledge was applied with an ethical responsibility with the purpose of synergising and analysing data across existing silo research:

- Grouping similar information;
- Identifying gaps within the literature;
- Indicating similarities and differences between disciplines in research.

The review incorporated a combination of research in a chronological, thematic, conceptual and methodological presentation. Using a systematic literature review to develop a theoretical framework for research defined the structure and specific intellectual content. Due to ergonomic, political and social influences that drive IAQ, I have decided to present initial findings from my review into ten sub-chapters, with the intention to take the reader on a journey through the IAQ arena.

2.6.1 Literature Review Search Strategy and Methodology

Search Strategy

A theoretical framework was developed to assist with the literature review to enable a structured, innovative approach to exploring the data. A search strategy was implemented to structure the review of literature on indoor air quality and to ensure the research is relevant, unbiased and chronologically dated to ensure current evaluations. A thematic review of literature was organised around key topics within indoor air quality, in particular the different political, social and economic influences and the landscape of Global, European and UK interface.

The objectives of the methodology were to:

- Centrally collate information on indoor air quality from disparate and diverse resources;
- Identify perception, knowledge and understanding required to raise indoor air quality awareness with OHS and EH practitioners;
- Investigate the drivers and barriers for promoting indoor air quality;
- Understand how other similar initiatives have succeeded.

Due to the diverse disciplines of evaluation a broad range of sources were encompassed including academic and professional journal articles, books, government reports, published research and conference notes. Ensuring material is concise, up-to-date and sourced from reputable journals, mindful of bias within peer reviewed publications, political bias in reporting and commercial products/service promotion. There are several books that provide different aspects to indoor air quality, essentially the material has been written for a particular readership, such as engineers, technicians and students. Maroni et al., (1995), Marsik and Johnson (2008), Burroughs and Hansen (2004), Diamond and Grimsrud (2004) and Bas (2003).

The most comprehensive book that delivers a diverse contribution from medical doctors, architects, engineers, chemists, biologists, physicists and toxicologists to discuss all aspects, including building design, health effects, medical diagnosis and toxicology of indoor air pollutants is a publication by Maroni et al., (1995) from the Netherlands. The thematic structure has limited the cross fertilisation of practical application, as the data is presented in a silo approach; concepts do not exist in a vacuum and the silo effect of current text, although excellent as a reference source, has limited transferability into a working environment. Despite the US influx of books on indoor air quality, there is currently no specialised UK indoor air quality book in the market place; the UK has limited resources to discuss the differences in building and fabric design, methods of ventilation, varied climates, UK legislation and best practice. The Health and Safety Executive also offer no specific publications directed at indoor air quality, only a simple guide for general ventilation. Any specific UK books are over 20 years old (Brooks and Davis, 1991).

Wiley-Blackwell publishes the bi-monthly International Journal of Indoor Environment and Health (IJIEH) which provides a source of original research within the indoor environment of non-industrial buildings. With 31 editors representing 11 countries from USA to South Korea, there is no UK representative. Again the papers represented are technical details of specific airborne pollutants and the impact on occupants, there is limited discussion focusing on application within a working environment. Following a review of papers presented in a 12 month period of the project (January 2010 – 2011) only two papers discussed non-technical subjects, Nazaroff (2010) debated the role of the IJIEH publication as an international, multidisciplinary, research journal; and Sundell (2010) questioned why the scientific community focus on one ‘pop’ problem at a time. Although many of the papers suggested modelling and control strategies for specific contaminants there was a lack of detail regarding the application and management of IAQ as a multi-disciplinary subject.

Therefore I decided to limit the use of IAQ books and access information via more appropriate resources. The majority of data used for my project was accessed through electronically available mediums, sourcing literature via PubMed, Science Direct, Athens, Open Gray, Google Scholar and other scientific and academic depositary databases; websites of relevant organisations, such as the HSE, BOHS, ASHRAE; and manually searching key relevant journals including Indoor Air. I used a range of search wording and phrases, as illustrated below in figure 1, creating a field of literature using a Boolean search approach.

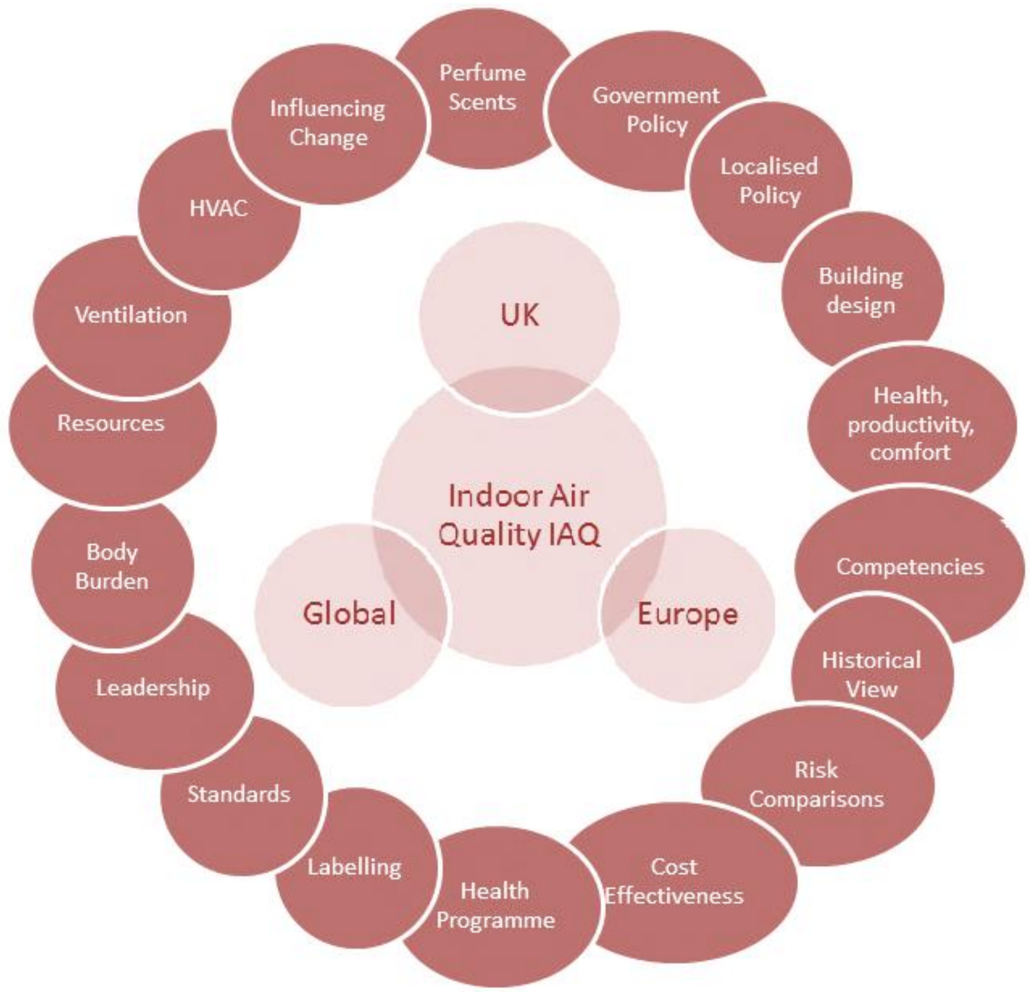

Figure 1: Combination of search words used.

Key words used during strategy search, cross referencing within a UK, Europe and Global setting.

I also included searches within organisations' resources and conferences that discuss IAQ as a source, including UKIEQ, ISIAQ, IAQA, IEAQC, BRE, WHO, CIBSE, RIBA, REHVA and ASHRAE. Non-peer reviewed articles, including newspaper articles that were considered interesting, despite their usual brevity, lack of available detail and preliminary nature, were included, with consideration of reliable authors, such as the BBC. I also scanned social media, including LinkedIn, Facebook, Twitter and You Tube whereby individuals/organisations posted news and information. Such resources have an inclusion value because of the objective measure of readership exposure to an article and the influence of IAQ perception for lay readers. To ensure quality of peer and non-peer published papers, I reflected on Jefferson et al., (2002) quality indicators with table 3 below:

Table 3: Peer and non-peer literature quality indicators.

An evaluation of papers to decide on inclusion factors within a literature review.

Outcome / Definition	Ideal Indicators	Surrogate Indicators
Importance *Has the literature had an impact on IAQ?*	Changes in IAQ processes.	Media coverage. Citation rates.
Useful *Does it contribute significantly to IAQ debate?*	Contributed to a systematic review of IAQ.	Increase in contributions to peer and non-peer literature.
Relevant *Is the topic is relevant to my aims and objectives?*	Topic is relevant to readership.	Citation rates. Internet hit rates.
Methodology *Is there a valid approach to the methodology?*	Study findings are replicated to cross reference conclusions.	Methodology is tested.
Ethical *Does the paper discuss ethical considerations?*	Influences of social, economic and political issues are considered.	Study had ethical clearance.
Complete *Is all the text complete and rounded?*	There is no data missing or reference citations excluded.	Text and publication is complete.
Accurate *Is the information a true reflection?*	Raw data is presented.	Raw data is calculated. Surveys to test hypothesis.

I used a number of strategies whilst searching for literature, Stoan (1984) and Ellis (1989) describe six key areas:

- Footnote Chasing – A technique whereby I followed footnotes found in literature and moves backwards through references. Stenstrom and McBride (1979) indicate the popularity of this method for social science researchers;
- Citation Searching – By using citation indexes I could view other relevant literature and appraise inclusion value;
- Journal Run – By identifying relevant journals, I was able to refer to a bank of relevant articles;
- Area Scanning – Reviewing literature that is connected to the search topics, such as the broader understanding of HVAC engineer's competence whilst reviewing HVAC IAQ competencies;
- Search strategies in bibliographies – I found this approach helpful, as many scholars have personal or university websites that display their published papers;

Author searching – Certain well known authors in the field, such as Clements-Croome, Crump, Fanger, Fisk, Levin, Seppanen, Sundell, and organisations, such as ASHRAE, BRE, WHO can provide an effective method for topic searching.

Complementing the organic growth of my project, my search strategy has echoed a similar approach, I would describe my application of search methodology as a 'berry picker' (Bates, 1989).

> *'A bit-at-a-time retrieval of this sort is called berry picking. This term is used by analogy to picking huckleberries or blueberries in the forest. The berries are scattered on the bushes: they do not come in bunches. One must pick them one at a time*' (Bates, 1989, p4).

In a work based learning project the berry picking approach has enabled me to move through a variety of resources, encountering new ideas and concepts and understanding the contextualised setting of IAQ. Such approach has positively influenced cross fertilisation of ideas and has encouraged a broad range of topics for inclusion within this project.

The literature review acknowledged all resources and indicated where arguments may have certain validity; an appraisal of the strength of the research used by evaluating their study design and methodologies ensured proper measurements of risks, outcomes and statistical analyses were used within the project. Research with weak design or analysis, subjective data or crude appraisal of effective control measures were discarded.

To assist with managing the literature search, I used a software package called 'Mendeley Desktop', which enabled me to catalogue and organise papers into key topics to assist with berry picking activities.

2.6.2 Contextualised setting of IAQ

As discussed in chapter 1, page 14, Indoor Air Quality (IAQ) refers to the physical, chemical, and biological characteristics of air in the indoor environment within a building and how it relates to the occupant's physical and psychological health, comfort and productivity. A more technical definition of IAQ is related to how well indoor air satisfies the three basic requirements for human occupancy: thermal acceptability, maintenance of normal concentrations of respiratory gases, dilution and removal of contaminants to levels below health or odour discomfort thresholds (Passon et al., 1996). Lee, et al., (1996) discuss four fundamental developments in the last forty-five years which has focused our attention on indoor air quality:

- The increase of time spent within indoor environments;
- The increased dependency on artificial products;
- The increased occupancy density (open plan offices, limitation of working space);
- Advancements of energy conservation techniques (air tight buildings, re-circulated air).

Most individuals spend approximately 80% of their time indoors (Lebowitz and Walkinshaw, 1992) and are therefore exposed to the indoor environment to a much greater extent than the outdoor environment. Information obtained from laboratory and epidemiological studies suggests that indoor air pollutants are an important cause of avoidable morbidity and mortality in the UK's life expectancy (Department of Health, 2001), (Brunekreef and Holgate, 2002).

In the US contaminants in the indoor environment are reported to be 1,000 times more likely to be inhaled indoors rather than with outdoor air (Levin, 2007) and can be up to 10 times more polluted than outside air (US EPA, 2001). According to a 5-year-study carried out by the US Environmental Protection Agency (Greenfield, 1991) peak concentrations of 20 toxic compounds, some linked with cancer and birth defects, were 200-500 times higher inside than outdoors. It is necessary to note that these figures are based on US values and there is a need to exhibit caution in applying them directly to the UK in light of differing climatic conditions.

As our consciousness for external air quality improves, it would therefore seem evident that equivalent standards, focus and resources to manage health for exposure to outdoor pollutants must be applied to indoor air quality; and that we should not discriminate or differentiate between home, workplaces and/or public spaces.

There is considerable research to demonstrate that indoor air is more of a contaminant than outdoor air and that this is a contributing reason why we are seeing an increase in respiratory diseases, sensitivities and asthma (Department of Health, 2000). The potential effects of indoor air pollution include unpleasant smells and discomfort, cognitive and productivity reduction, lethargy, headaches, migraines, morbidity and fatal consequences of exposure to pathogenic organisms or chemicals. Further details are contained within appendix 1, page 391, which evidences the comparable studies of IAQ detailing epidemiological studies, business cases costs, health impacts and productivity and performance data of occupants.

Most of the toxins in our air are at low levels, but should not be disregarded as harmless; an accumulative effect within the body must be considered, including synergies and additive factors that act on specific organs. Despite the half-life of some components (such as radon, benzene) the dispersion through ventilation and application of air cleaning units, there is no doubt, no question any longer that the extent of contamination in the air we breathe is serious.

With work and home environments becoming more energy efficient, use of more synthetic materials and chemicals with an unacceptable cocktail of emissions and the use of odour brand marketing in an over saturated visual and audio market, the agenda of IAQ is becoming paramount; which is further compounded by a reduction in effective ventilation.

The Chemical Abstracts Service (CAS), a division of the American Chemical Society, is the global comprehensive source for chemical information since 1907. The daily inclusion of 36,000 new chemicals added to the CAS register contributed, in 2009, to their 50 millionth compounds registered (CAS, 2010), thus demonstrating the increasing use of chemicals within our society.

The Eurobarometer is the Public Opinion Analysis sector of the European Commission who survey and publishes the views of the European public with regard to a variety of topics, including social situation, health, culture, information technology and the environment. In 2013, they interviewed 25,557 members of the general public across 27 EU States to understand their awareness of chemicals within the products we eat and drink (83%) and whether they believe there are chemicals in the air we breathe (90%) (EU, 2013). The report further clarifies that (69%) respondents say that it is not possible to completely eliminate chemical substances from our daily life and 58% of respondents agree that new chemical substances can help in reducing the use of natural resources. Although only 43% of respondents believe it can contribute to a better environment.

Despite the optimistic views presented by the survey, A cautionary note should be added that the report also discusses the €449 billion European chemical industry, and the need to improve awareness and community trust to sustain the chemical industry.

Therefore should we expect the food we eat, the air we breathe and the water we drink to be uncontaminated and safe, regardless of whether the concern is from a bacteria or a carcinogenic substance. As educated consumers we can, to some extent, control what we ingest (dependent on labelling of ingredients), but our most vital organs, our lungs, are continuing to be affected by the harmful contaminants in the air we breathe every day, which we have limited control.

The disciplines of effective indoor air quality management have social, economic and political implications. The strategies for prevention and control of poor indoor air quality are just as important to the political agenda as external air pollution. Highlighting the importance of measuring indoor air quality can stimulate an appreciation for a cost effective model to recognise impact and potential losses for not managing economic value and profitability of good indoor climate. There are numerous organisations which are in charge of different aspects of air quality and chemical contaminants, of which the sources of information are disparate. There is a clear need to address indoor air quality within the UK more seriously and effectively, which should include a coordinated approach by the various organisations. A regulatory framework is also absent which could provide guidelines for a range of parameters using best practice standards from International and European research.

2.6.3 Historical Perspective

Understanding the history and context of IAQ provides indicators as to motivation for developing the subject matter, which subsequently provides an understanding for the impetus of future research.

The first known correlation between our built environment and health was described by Hippocrates in his masterpiece, 'On Air, Water and Places', a comprehensive study of climate in the largest sense, containing a mass of observations on air and prevalent winds; describing disease as a direct manifestation of an unhealthy situation rather than a form of punishment cast down by angry gods (Adams, 2011). Hippocrates revolutionary writing had provoked thoughts with other scholars including Aristotle who discussed the holistic approach of earth's main elements, including air. Such thinking bridged the relationship between biological science and the adjustment of organism to the environment.

Within the bible the Book of Leviticus (14, 34–57) describes a contaminated house and how living in buildings with dampness problems is dangerous to your health; the 'Law of Leprosy' provided guidance on how to cleanse the house, commencing with the identification of mildew as a plague on the inside walls of a house. Two birds, cedar wood, scarlet, and hyssop were prescribed for sacrificial procedure for cleansing the house by a Priest (Bonar, 1851).

Within the medieval era new knowledge was developed understanding that air in a building could transmit diseases in crowded rooms and open fires used to heat buildings, created poisonous smoke. In an attempt to remove smoke, King Charles I in 1600 decreed that no building should be built with a ceiling height of less than 10 ft (3 m), and that windows had to be higher than they were wide (Kühnl-Kinel,2000). Although these benefits were expunged in 1696 due to the introduction of King William III's window tax, which banded payments based on number of windows within a building.

The Window Tax was not repealed for 155 years until 1851 when campaigners argued that it was a 'tax on health', and a 'tax on light and air', as well as being an unequal tax with the greatest burden on the middle and lower classes (Glantz, 2008). During those 155 years, windows were blocked up and building erected with fewer windows during a growing industrialised revolution and urbanisation (Ward, 1952).

The epidemiological findings of associations between health effects and working in certain heavily polluted premises failed to prevailed until the 18th century. In Italy in 1713, Bernardino Ramazzini published 'De Morbis Artificum Diatriba (Diseases of Workers)' outlining the health hazards of chemicals, dust, metals, repetitive or violent motions, odd postures, and other disease-causative agents encountered by workers in 52 occupations (Wright, 1940).

Whilst in London in 1733, polymath John Arbuthnot wrote a popular work of medicine called 'An Essay Concerning the Effects of Air on Human Bodies'. He argued that the air itself had to have enormous effects on the personality and persons of humanity; and he believed that the air of locations would result in characteristics of the people, as well as particular maladies.

> '*That Difeafes of the lungs, as far as they are, not the product of bad diet, depend chiefly upon the qualities of the air, seems evident"* (Arbuthnot, 1733, p188).

During the 18th Century understanding of human metabolism, including composition of exhaled gases, contributed towards our greater understanding of air. The English theologian Joseph Priestley is credited with the discovery of oxygen; he also discovered how plants change the composition of air by releasing oxygen in 1771. Priestley put a sprig of mint into a transparent closed space with a candle that burned out the air until the flame went out. After 27 days, he relit the extinguished candle again and it burned perfectly well in the air that previously would not support it (Johnson, 2008).

Johnson attributed much of the success of Priestley to his ability to share information with the purpose of building on ideas.

> *'There is no magician's reserve in Priestley's cabinet of wonders; He truly wanted you to see everything*' (Johnson, 2008, p68).

Priestley dramatically changed our relationship with our environment, characterising different gases including nitric oxide, anhydrous hydrochloric acid, ammonia, nitrous oxide and oxygen; which he wrote extensively about within volume one of six volumes entitled 'Experiments and Observations on Different Kinds of Air' *(*Priestley*, 1775).*

During the previous century carbon dioxide or 'wild spirit' was one of the first gases to be described as a substance distinct from air by 16th century Flemish scientist Joan Baptista van Helmont (Pagel, 2002). Antoine-Laurent de Lavoisier, the prominent French scientist acclaimed for the first list of elements and construction of the metric system, drew an association between oxygen consumption and carbon dioxide (CO_2) release (Grey, 1982). Prior to this discovery, medical practitioners believed that breathing was primarily a way of cooling the heart, as opposed to the importance of the composition of air (Sundell, 2004).

Xavier Bichat, a French surgeon and professor of medicine in France described the triple alliances that are necessary for life as the function of the heart, lungs and brain. Despite his short 30 years of life, Bichat's meticulous study of the human anatomy and physiology, via autopsies, shaped our understanding today. Bichat deconstructed the body into elementary tissues, defining three types of tissue membranes – fibrous, mucous and serous without the aid of a microscope (Barbara, 2007).

In his General Anatomy, Applied to Physiology and Medicine of 1801, Bichat provided an holistic approach of how our body is connected and explains the function of the lungs to mechanical expand and change black blood to red. He described diseases of the lung tissues and also discusses how the respiratory system can influence the cooling of body temperature (recognising different tissues secrete different temperatures) (Henderson, 2011). In July 1802 Bichat left a ward at Hotel-Dieu hospital in Paris, following an examination of some macerated skin, and fell on some steps, later reported as he fainted. A headache, fever and convulsions which finally led to Bichat becoming comatose, Bichat died 14 days later, his death recorded as unspecified, but potentially a fever from the tainted air of his dissecting room (Krush, 1983).

Bavarian chemist Max Joseph von Pettenkofer first noted that stale air was due to the presence of trace quantities of organic material exhaled from the skin and the lungs. He proposed that air weakened the human resistance against agents causing illness. In Pettenkofer's view CO_2 was not important in itself; but was an indicator of the amount of other noxious substances produced by man (Trout, 1977). Pettenkofer initiated the conversation regarding minimum concentrations of pollutants, proposing that air was not fit for breathing if the CO_2 concentration (with man as the source) was above 1000 ppm, and proposed that:

> '*Good indoor air in rooms where persons stay for a long time should not exceed 700 ppm in order to keep the persons comfortable'* (Sundell, 2004 p2).

Such was Pettenkofer's conviction regarding the atmosphere; he believed that cholera was spread via the air rather than directly from person to person. Essentially reinforcing the miasmatic theory of diseases, such as cholera or the Black Death; caused by a *miasma* (ancient Greek for pollution), a noxious form of bad air.

In 1881 Heyman, published ‘The indoor air of our home’ in which he discussed health effects of indoor air in rooms that were insufficiently ventilated. Such unclean air, draught and dry air could cause nausea, headache, rheumatism, pain in the nerves, common cold, catarrh or irritation in the lower respiratory system and a sensation of dryness in the throat; a description close to today’s sick building syndrome (SBS). Heyman (1881) concluded that we cannot rely on natural ventilation if we want to live in clean air.

The correlation between our environment and health developed with similar initiatives exploring alternative routes of entry into the body, including the treatment of ingested drinking water. In particular epidemiologist John Snow was able to trace multiple cholera deaths to a single pump in Soho, London, which had become contaminated by a nearby leaking sewer in September 1854 resulting in 500 lives lost in just ten days (Hempel, 2006). Percival Potts**,** an English surgeon, who drew a correlation between cancer and the skin absorbing environmental carcinogens caused by chimney soot; Initially Potts diagnosed scrotal cancer which resulted in the Chimney Sweepers Act 1788 (Brown and Thornton, 1957).

Discovery of oxygen and carbon dioxide, the industrial revolution, overcrowding of rooms and the spread of diseases raised the attention of the need for fresh air. The development of modern hygiene from mid-19th century provided a better understanding of the composition of air and the relationship with health, providing an understanding that ventilation contributed towards good hygiene.

Brown-Se´guard and d’Arsonval 1887 (Bedford, 1948) had proposed that poisonous substances were given off from the lungs within their anthropotoxin theory. However Pettenkofer conducted a number of studies between 1880 and 1901 searching for such evidence and found no toxic effects other than high concentrations of CO_2 which was reported as having no ill health effects (Trout, 1997).

Therefore the warmth and odorous conditions created in crowded rooms were merely perceived as a source of discomfort rather than ill health; such bodily emissions were to be removed by the use of ventilation. Despite Pettoker views, bad or stale air was seen as a cause of ill-health, particularly in overcrowded, reduced ventilation environments. Philanthropist Reverend Stephen Hales (1700-61) developed the idea of introducing bellows within hospitals, jails, ships and mines successfully reduced diseases, possibly driven by the death of his brothers from Gaol Fever within Newgate Prison (Schofield, 1980) .

Along with ventilation, cooling systems were introduced by William Key in the royal Victoria hospital, Belfast (1903) along with Henry Lea (1839-1912) who also developed the Birmingham general hospital artificial ventilation (1893). The notion of comfort for occupants developed ventilation further, with Dr. David Boswell Reid's (1805-63) House of Commons, architect Sir Alfred Waterhouse (1830–1905) London's Natural History Museum, designer Charles Rennie Mackintosh (1868-1928) Glasgow School of Art, and Wilson Weatherley Phipson (1838-91) heating and ventilation system into such prestigious places as the Strand Music Hall (1864), Glasgow University (from 1864), Royal Holloway College, Egham (1882); and in London, the Natural History Museum (1873), Royal Albert Hall (1871), Alexandra Palace (1874) and the Empire Theatre in Leicester Square (1890) (Roberts, 2009).

Ventilation comes from Latin 'ventilare' meaning 'to expose to the wind' with the objective to create an indoor air quality environment for persons and processes, improving an unventilated building by diluting and removing the pollutants. Thomas Tredgold (1788–1829) was an English engineer and author who published the first text on heating, 'The Principles of Warming and Ventilating Public Buildings' (Tregold, 1824); he calculated the loss of heat based on ventilation extraction, suggesting 2 ½ cubic feet per minute for each person to reduce body heat temperature rising 5°F. (Roberts and Ferris, 2012)

In 1844, Hermann Rietschel developed the first textbook on guidelines for mechanical heating and ventilation, which is, in many ways, still current and included guidelines on outdoor airflow requirements and dimensioning of both natural and mechanical ventilation. The view that air quality was not merely comfort continued to be supported, Winslow and Palmer (1915) had initially reported a decrease in food consumption in unventilated occupied rooms, which was considered due to low oxygen levels, such claims were pinpointed by further studies examining the results of heated houses from vacuum cleaners which produced the same apathy results (Winslow and Herrington, 1936).

Yaglou et al., (1936) provided the breakthrough when studying ventilation rates of occupied rooms, insinuating that the desired favourable impression of odour, freshness, temperature, humidity, drafts and other factors affects the senses. Yaglou et al., (1936) showed that simple recirculation of air did not affect the odour strength and concluded that evaluating just body odour as a source of pollution, a room can be ventilated just as well with an outdoor air supply of 8 l/s.p (litres per second, per person). The specified rate of 8 l/s.p is still used today within U.K. Building Standards (Department for Communities and Local Government, 2006). Yaglou et al., (1936) also experimented with humidifying and dehumidifying the re-circulated air and found that both techniques, especially dehumidifying, reduced the odour strength, resulting in a reduced need of outdoor air supply for odour control. Thus demonstrating how odours or bacteria can be suspended within the air on water droplets. Such experiments resulted in today’s dry fresh air intake, successfully reducing body odours, but paradoxically impacting on occupant’s health with the low humidity.

Environmental issues within the beginning of the 19th Century until the 1960s typically focused on air quality from industrial processes, which provided extensive research that forms the backbone of workplace exposure limits today, appendix 10, page 419.

Factory workers led a short and miserable existence in their harsh environments, exposed to the chemical industrial processes of the industrial ages; indeed in some instances exposure and consequential related health conditions were seen as tolerable for industry. Such as the young matchmaker girls exposed to the vapours from white phosphorus, resulting in phosphorus necrosis of the jaw or 'phossy jaw', an affliction that caused abscess in their gums eventually rotting their jaws and if left untreated resulted in death from organ failure. The trade unions, in particular Herbert Burrows (Union President), had initially voiced their tolerance of the condition to prevent work from being transferred to overseas (East London Observer, 1888). Sheffield trades men who made cutlery had a life expectancy of 30 years, developing chronic Grinder's asthma (Engels, 2009). Haters and millers who were exposed to the use of mercury whilst curing pelts, exposing the workers to mercury vapours causing neurological damage, including confused speech and distorted vision (Emsley, 2005). A depiction within Cheshire born Lewis Carroll's 1865 Alice's Adventures in Wonderland's Mad Hatter character (Cohen, 1996), Carroll would have resided near the hat factories and potentially witnessed the effects of mercury.

Since the 1930s there has been little scientific effort within the field of ventilation, instead, perceived air quality (comfort, odours) has been the key focus. Fanger et al., (1988) also stressed the comfort aspect of indoor air pollution justifying that it is normally the perception, not actual risk that causes people to complain; perceived air quality is a valued comment, particularly regarding productivity of an individual who feels uncomfortable. It may also provide a first indication of possible health risks. Fanger (1988) proposes that human senses are usually superior to chemical analysis of the air. Fanger used simple descriptive terms of an occupant's understanding of whether the air felt fresh or stuffy, good or bad, acceptable or unacceptable. Franger (1988) introduced the concepts of olf (emission rates of a person – bio effluents) and decipols (concentration of air pollution perceived by humans) as a quantifiable measurement.

The perception of the problem draws an understanding to the correlation of symptoms, as an example in December 1952 when London was gripped by a thick layer of smog over the city. A period of cold weather combined with an anticyclone and windless conditions, collected airborne pollutants mostly from the use of coal. The smog enshrouded the city from Friday 5th to Tuesday 9th December 1952, dispersing after a change in the weather. The combination of fog and industrial airborne pollution created a dirty yellow-brown haze, with visibility dropped to 15 metres (50ft) or less; hence the term pea-soup fog (Peirce et al.,1998). The city came to a complete stand-still, with schools, workplaces and transportation closed. Following the event, medical practitioners had reported that 4,075 people had died prematurely and 100,000 more were made ill due to the smog's effects on the human respiratory tract (Peirce et al.,1998). Due to the visibility of the smog, the correlation between the conditions and significant effects were directly attributed, which resulted in the Clean Air Act 1956. The smog was a visible hazard that could be seen and provoked a public emotion as to acceptable standards, raising the consciousness of the air quality plight. Perception has a significant role in the response of occupants to latent health effects; and should be discussed within the debate of how to raise the awareness of IAQ.

Within America, Rachel Carson, an American marine biologist, started to raise the environmental debate and had expressed concerns regarding the use of dichlorodiphenyltrichloroethane (DDT) as an insecticide sprayed onto crops to kill mosquitoes. Carson wrote a book in 1962 called Silent Spring (Carson, 2002), which meticulously described how DDT entered the food chain and accumulated in the fatty tissues of animals, including human beings, causing cancer and genetic damage. Carson ardently wrote that DDT and other pesticides had irrevocably harmed birds and animals and had contaminated the entire world food supply.

The book’s title was meant to evoke a spring season in which no bird songs could be heard, because they had all vanished as a result of pesticide abuse. Its title was inspired by a poem by John Keats, La Belle Dame sans Merci, which contained the lines

> ‘*the sedge is wither'd from the lake, and no birds sing’* (Bloom, 2006 p91).

Carson’s publication echoed this view with ‘A Fable for Tomorrow’ depicting a nameless American town where all life from fish to birds to apple blossoms to human children had been silenced by the insidious effects of DDT.

> ‘*Then a strange blight crept over the area and everything began to change. Some evil spell had settled on the community….no witchcraft, no enemy action had silenced the rebirth of new life in this stricken world. The people had done it themselves’* (Carson, 2002, p2-3).

Although Carson is concerned with our external environment, I found Silent Spring an invigorating read; drawing parallels to my own work. Carson’s thought provoking illustration is acclaimed as generating an elevated perceived consciousness within the environmental movement. Undoubtedly this will be a book I shall return to maintain my momentum within my chosen field.

Within the following years other environmental concerns were voiced with recognition such as radon in the late 1960’s, formaldehyde in the early 1970’s, house dust mites and SBS (sick building syndrome) in the late 1970’s (Sundell, 2004). During the oil crisis in the 1970’s more attention was given to the introduction of energy saving measures in buildings (Hammond and Stapleton, 1991).

This resulted in sealed energy efficient buildings, with mechanical systems controlling airflow and comfort factors (heat, humidity), initiating a reduction in the amount of outdoor air being supplied into buildings and further exasperating the growing contaminants from within.

In addition to the contribution of building materials, furnishings, occupant activities, and building (HVAC) systems; products such as perfumes, air fresheners and marketing scents are significantly contributing to the synthetic composite.

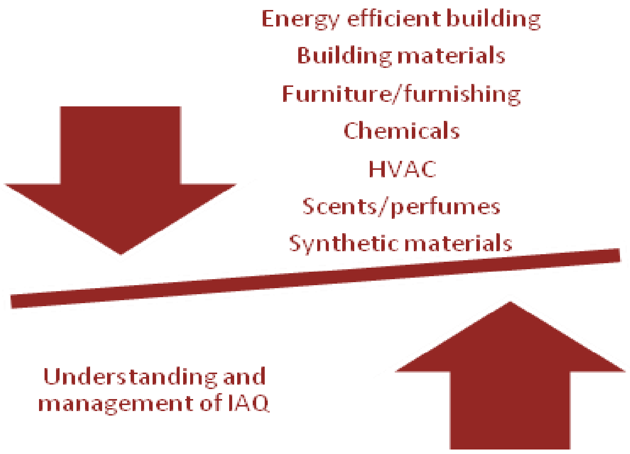

Figure 2: Balancing IAQ.
An illustration of creating a balance between developments in building design and understanding of IAQ impact.

As the range of building materials, chemicals and perfumes grow, there if a need to balance such risks with understanding IAQ and the impact of such rapid changes. The developments have occurred at such a rate, that our knowledge and understanding of the impact is limited. To address the balance, further focus is required on the understanding of IAQ permutations and the active management of indoor contaminants, as I have illustrated in figure 2 above.

2.6.4 IAQ Components

Each day we take over 20,000 breaths and breathe about 35 pounds of air; (Carle, 2006); and in our lifetime, we may take about 625 million breaths (Carle, 2006). We breathe in and out anywhere from 15 to 25 times per minute. One fifth of the air we breathe is made up of oxygen (21%) with nitrogen (78%) and the remaining is small amounts of argon, carbon dioxide and other gases and water vapour (1%) (Taylor et al.,1997). There are many key components contributing to the air we breathe.

Carbon Dioxide

The 5.6% of carbon dioxide in the air we breathe out from our lungs can build up within a room with insufficient ventilation. Carbon dioxide concentrations have often been used as an indicator as to the acceptability of indoor air quality and the suitability of air flow exchange. However carbon dioxide levels can also be contributing factors towards sick building syndrome. There is strong evidence to suggest a correlation between carbon dioxide build-up and decreased levels of health, comfort and productivity (Seppanen et al., 1999). 2800 ppm carbon dioxide concentrates can result in a surge of health complaints and a significant reduction in productivity with occupants feeling lethargic. Indeed, studies have shown that a level of 1000 ppm carbon dioxide will reduce the ability to concentrate by 30% - a significant productivity reduction (Myhrovold et al., 1996). Such studies have been conducted in offices and schools (Bakó-Biró, 2012); however the risk increases for skilled tasks/role, such as surgeons, aircraft pilots etc. Satish et al. (2012) proposes critical thinking is reduced by as low as 600ppm, proposing that the direct adverse effects of CO_2 on human performance may be economically important and may limit energy-saving reductions in outdoor air ventilation per person in buildings. This is further reinforced by Clements-Croome (2003) proposition that staff salaries typically are about 90% of costs and expenditure for maintenance, energy, cleaning and administration are only about 5% of staff costs, thus clarifying the importance of productive staff.

Temperature

The Workplace (Health, Safety and Welfare) Regulations 1992, Regulation 7 specifies during working hours, the temperature in all workplaces inside buildings shall be reasonable 13°C (physical) 16°C (sedate) (HMSO, 1992).

The Health & Safety Executive defined thermal comfort between 13°C (56°F) and 30°C (86°F) and recommend that employers should adopt a reasonable comfort standard; quoting 80% of the workforce should be thermally comfortable (HSE, 2012, p1). Thermal comfort may be a subjective matter, but there is a strong relationship between occupant's comfort and productivity (Parsons, 1993). De Dear et al (1993) proposal that 23.5^{o}C is the temperature most people prefer, despite the 35% who still want the air warmer or cooler. Leaman and Bordass' (2000) description of productivity killers, includes comfort (personal control), responsiveness to needs, ventilation types (size, volume of space), work groups (layout of space) and design intent (communication to users and occupants). Leaman and Bordass (2000) clearly indicate that perception is as important as actual temperature; they advised caution against ignoring marginal needs of occupants.

The World Health Organization (WHO, 1987b) state that 18°C plus a 2 – 3°C warmer minimal temperature for rooms occupied is preferable, although we should note the recommendation was discussed in conjunction with reducing the potential for respiratory diseases in sedentary elderly, young children and the disabled.

Humidity

Health effects associated with humidity can also arise from the occupant's environments. A primary source of health conditions can arise from a building with high humidity (70%RH>), which can induce:

- Toxic or allergenic moulds - *Cladosporium herbarum, Eurotium herbariorum, Penicillium spp. Aspergillus spp. Wallemia spp*. (Singh, 2002)
- Moulds from Dust - *Alternaria alternata, Aspergillus versicolor, Aureobasidium pullulans* (Singh, 2002)
- Corrosion and moisture related deterioration of materials;
- Carpets and fabrics can be exposed to dust mites and mildew. (Singh, et al., 2010).

There is also evidence to suggest the high humidity increases emissions from volatile organic compounds (VOC), in particularly formaldehyde, which is a common VOC in the workplace (Little, 2008). High humidity (60%>) can make people feel warmer than the actual temperature and can induce health conditions such as asthma, contribute to respiratory infections or cause Dyspnoea (WHO, 2009); low humidity (40%<) can create health conditions and sensitivity for individuals (Mallick, 1996). Low humidity can dry out the mucus linings of the respiratory system, thus reducing the effectiveness of the body defences to filter foreign particles that enter the nose and throat. It can also dry the atmosphere and induce static electricity. The condition may also affect the infrastructure of the building, drying paint finishes causing them to crack and contribute to shrinkage in natural products such as wood. A measurement called a humidex is used to provide a combined effect of temperature and humidity on cooling of the human body. As an optimum condition, people generally find 40%-60%RH acceptable, with 45%RH the most comfortable (Fang et al., 1998).

Volatile Organic Compounds

Volatile Organic Compounds (VOC) is a collective term given to a variety of chemical compounds that have a high enough vapour pressure to evaporate into the atmosphere at normal room temperature entering our indoor environment. Nebel et al., (1992) considered that about 350 different types of VOCs are present in our indoor environment; however with the increase of building materials, furnishings and products, it is potentially considerably higher). VOCs are emitted from a number of sources including processes, furnishings, equipment, substances and even people.

Types of Organic Compounds:

- Benzene (furnishings, perfumes, paints);
- Ethylbenzene (plastics);
- Xylenes (solvent in printing);
- Methylene chloride (solvent, paint stripper, aerosol spray propellants);
- Tetrachloroethylene (solvent in dry cleaning, paint stripper);
- Formaldehyde (furnishings, carpets, preservation, disinfectants, solvents,);
- Toluene (paint thinners, solvents);
- Nonanal (used in perfume);
- Phenol (used in cosmetics, hair dye);
- Isopropanol (solvent, cleaner);
- Acetone (solvent, paint thinner, nail polish remover).
- Bioeffluents (butyric acid, sweat, body odour)

This list is not exhaustive. Many of the compounds can enter into your human tissue and stay for years. High concentrations of VOCs can affect your central nervous system, causing depression and/or sensitivity to certain compounds. (Maroni et al., 1995). A few of these VOCs, for example formaldehyde and benzene, are considered by many authorities to be proven or probable human carcinogens. Benzene is classified as a known carcinogen based on occupational studies in adults that demonstrated increased incidence of several types of leukaemia in exposed adults (US EPA, 1998) Formaldehyde is classified as a probable human carcinogen by the US EPA (1999) and as carcinogenic to humans by the (WHO 1999). The degree of effect on the body is dependent on the contaminant, the exposure situation, the concentration, length of exposure and how the contaminant is metabolized by the body, which all contribute to the potential interaction of toxicokinetic and toxicodynamic levels manifested from exposure to a VOC.

<u>Particulate Matter</u>

Particulate matter (PM) is the name for a wide range of particles that are small enough to be carried by the air and therefore be breathed in by people. They can be solid or liquid, or a mixture of both. The solid particles come in numerous shapes and sizes and may be composed of different chemical components. They are divided into two principal groups:

- Coarse particles which are less than 10 microns (µm) and more than 2.5 microns in diameter can penetrate into the respiratory system and lungs and can cause damage. One micron or micrometre is one millionth of a metre (10^{-6}) or approximately 1/25,000 of an inch (Lee, et al., 1996).
- Fine particles measuring 2.5 microns or less in and can penetrate deep into the body's respiratory system. A single hair from your head averages about 70 microns in diameter – making it 30 times larger than the largest fine particle (Lee, et al., 1996).

The finer particles pose the greatest threat to human health because they can travel the deepest into the lungs. Health effects vary depending upon the characteristics of the dust and any associated toxic materials. Dust particles may contain lead, pesticide residues, radon, or other toxic materials. Other particles may be irritants or carcinogens (e.g. asbestos).

Working/living near a busy road can increase the levels $PM_{2.5}$ from vehicle exhausts. A tremendous number of studies show a link between this particulate pollution and cardiovascular disease, respiratory disease and cancer (National Research Council, 2004), (Dominici et al., 2006), (Pope et al., 2010). Despite such evidence there is limited data to analyse whether planning policy has been affected and consideration is given regarding health impacts of occupants whilst planning applications are deliberated. External air is monitored, but indoor air is not made an equal priority.

Reflecting upon my search of occupancy health and exposure to road effects, the research is weighted in discussion around noise pollution, which provides a direct impact on our audio sense and thus creates visibility of a risk. The exposure of particulate pollution and residential building locations is an area I would wish to explore following my DProf programme.

Biological Agents

Common biological contaminants include mould, dust mites, viruses and bacteria. Many of these biological contaminants are small enough to be inhaled. There are approximately 1.5 million species of fungi, with an estimated 1000 species that have evolved within the built environment (Singh, 2005). Fungal growth usually requires RH>70% and can grow in a wide climate range (-10°C to 65°C) (Singh, 2005). Fungi produce toxic compounds (mycotoxins), which can cause liver, kidney damage, respiratory reactions (Hendry and Cole, 1993). 30% of people show allergic reactions to fungal spores (wheeze, cough, shortness of breath) **(**Kurup et al., 2000) and immunosuppressant disorders**.** Biological contaminants are, or are produced by, living things and can often be found in areas that provide food and moisture; such as damp or wet areas of cooling coils, humidifiers, condensate drains, or unvented bathrooms which could be mouldy. Textiles, carpets and other areas where dust collects may accumulate biological contaminants. Ventilation duct dust can contain up to 50,000 bacteria per gram of dust, with filters containing up to 6,700 bacteria per gram of dust (Cornell University, 2012). Bacteria can cause many building-related illnesses, such as Legionnaire's disease, allergic rhinitis, asthma, and hypersensitivity reactions (Burger, 2006), although not all bacteria are pathogenic.

Managing indoor air quality is challenging because it crosses many disciplinary boundaries, from architecture and building design to occupational health and human behaviour; and covers many types of variables relating to buildings, including their layout and technology, the organisations which occupy them, the ventilation systems and the people themselves.
Historically we have also evaluated the impact of indoor air quality as separate topics; however, the combined variables within IAQ can potentially increase the risk to occupants and add to the challenge of IAQ management.

As discussed, the complexities of interaction between the IAQ contributors can increase a risk, which is often neglected in discussions of silo research literature. (A term I have developed from the existing depreciatory description of silo thinking, whereby information is not discussed in context or compared with other sources). As examples, carbon dioxide and/or humidity increasing in a space can affect the perceived temperature of an occupant, who often feels warmer despite no actual temperature change. The increase of temperature and/or humidity can increase the rate of release from VOCs, increase exposure limits of occupants; humidity can increase the suspension of VOCs in the atmosphere. Combined contaminants research is complicated due to the variables within our environment, however to prioritize risk management of such pollutants and the effect on occupants, a real world application is required.

2.6.5 Critique of Combined Variables

The rationale regarding a silo approach can be attributed to the monitoring process and exposure limits that are typically conducted on a single chemical basis. Indoor environment exposures are complex mixtures of substances from different sources which collaboratively contribute to the overloading, body burden and toxic effect. Due to the complexity of indoor air pollution and its variability, including exposure time, sensitivity of occupants and ventilation rates, an assessment of this mixture is complex. This approach has only been used in a few cases, where evaluating sensory irritation was the key objective. Hempel-Jorgensen et al., (1999) studied eye irritation from exposure to N-butanol and 1-octene; and, Nielsen et al., (2007) research of human and animal studies evaluated irritation of eyes and upper airways. However these studies investigated short-term effects of acute irritation, as opposed to long term, chronic conditions.

Reviewing environmental studies, Mauderly and Samet (2009) reviewed 36 laboratory studies of combinations of ozone with other pollutants to determine synergisms and antagonistic outcomes, determining:

> ‘S*ynergisms among environmental pollutants has been established, although comparisons are limited, and most involved exposure concentrations much higher than typical of environmental pollutants. Epidemiologic research has limited ability to address the issue explicitly’* (Mauderly and Samet (2009, p1).

Despite such outcomes the discussion of understanding air pollutants, whether indoors or outdoors, are perceived as an important insight into health and the complex air we inhale.

The Committee of the Health Council in the Netherlands tentatively evaluated the measurement of individual VOCs; declaring the activity as limited by the analytical window determined by the methodology for sampling and low concentrations in indoor air. Therefore, suggesting the evaluation of health impact from total volatile organic compounds (TVOCs) (HCN, 2000) as a suitable predicator; recommending the maximum tolerable pollution of indoor air by VOCs to be between 0.2 and 3.0 mg/m^3; giving as recommended a cumulative limit value of 0.2 mg/m^3 for VOCs not showing carcinogenic, reprotoxic (toxic to reproduction) or sensitising properties. These recommendations were adopted into the WHO's air quality guidelines (WHO, 2000). However, because the composition of total VOCs varies from place to place this may only be used as a very general indicator. The main problems encountered in applying the combined effect approach, is the limited data available on interactions among more than two chemicals; and that TVOC measurement does not address issues of chronic toxicity.

At EU level there is no general recommended approach to conduct a risk assessment for chemical mixtures or for combined effects due to concomitant exposure to different chemicals through various body entrance routes (inhalation, absorption, ingestion, injection). In addition to the unknown combined effects of disassociated measuring approach, additional variables also challenge our perceived understanding regarding exposure:

- Correlation with factors such as humidity, air changes and temperature (which increase emissions from VOCs, biological matter and suspend contaminants in the atmosphere longer);
- Exposure patterns (short term, long term);
- Half-life and dissipation rates;
- Toxicokinetic and toxicodynamic levels;
- Ventilation flow, air extraction capacities, recycling air mix;
- Varying decomposing rates of building materials, finishes and furnishings (rate of emissions);

- External air intake (contamination in external air used as source for internal HVAC air);
- Effects and risks of products which emit indoor air pollutants that can react within indoor air (such as fragrances - limonene (orange scent), β-pinene (pine scent), and ethanol and acetone (often used as carriers for fragrance chemicals). (Steinemann, 2010);
- Exposure-effect-relationships especially in vulnerable groups (young, old, asthmatic conditions);
- Spread and movement of contaminants within indoor air (air flow/movement);
- Increase of ultrafine particles / nanoparticles from man-made processes.

The complexities and variables of combined contaminants are seen as too challenging in existing methodological substance evaluations. The European's Scientific Committee on Health and Environmental Risks consider that:

> *'The risk assessment which takes into account the combined exposure and cumulative effects of the pollutants in indoor environment is seldom possible. Mostly, there are not enough relevant data and the available methods may not fit the case'* (SCHER, 2007, p13).

Billionnet et al., (2012) critically appraised literature relating to the multi-pollutant effects of 5 indoor pollution and 10 outdoor pollutions using the probabilistic Hierarchical Bayesian model, thus providing a statistical output of diseases and symptoms. Billionnet et al., (2012) recommended the model for consideration in public health decisions.

Considering Billionnet et al., (2012) conclusion, the application of applying a statistical risk factor to the management of multi-pollutants can assist with prioritising risk management, particularly when comparing risk against the tolerable risk framework, as discussed on page 273. Mauderly et al., (2010) proposed a question within the title of their paper 'Is the air pollution health research community prepared to support a multi-pollutant air quality management framework?' The authors conclude it is possible to achieve a multi-pollutant framework within the next 10 years, but advised caution that resources needed to improve appropriately.

The US EPA have prioritised their focus on multi-pollutant exposure, declaring their vision to support cross-disciplinary research of toxicological, clinical, and epidemiologic study designs, statistical and other data analysis methods, and air quality models, ensuring the 'toolbox' of research is implemented to evaluate health impacts of air quality (US EPA a, 2012).The complication of air pollution compared with alternative forms of multi-component epidemiology studies (such as ingestion of medications, or contaminated sources) is the complexities of the environment that add additional dimensions to the health impact. The air quality community have acknowledged the requirement for further investigative research and need to consider an appropriate model that encompasses such complexities, but also include a measurable method for risk comparisons, particularly if the community are seeking funding to manage air quality research for the future.

Bio-monitoring provides an advantage over exposure estimates by measuring uptake, effects of the exposure, the body's response to the exposure and the potential of clinical disease (Baker et al., 2012). However, such biomarkers can also be influenced by population variables. Bio-monitoring has been discussed later within this project on page.329.

2.6.6 Fragrance - The Sleeping Giant of the Future

An additional complication in challenging our understanding is the perception and acceptability of a contaminant by the occupant. Despite the various literature discussing IAQ, there has been a gap in understanding occupant's reaction to a pollutant based on their opinion of risk. With the increasing use of scent marketing and personal fragrance application, acceptability of such pollutants creates a significant concern for our generation. The lack of association papers discussing perfume requires addressing and the significance of the problem provides justification to devote a sub chapter to this topic.

Smell is a socio-cultural phenomenon, associated with varied meanings. Synott describes odour as:

> '*A boundary-marker, a status symbol, a distance-maintainer, an impression management technique, a schoolboy's joke or protest, and a danger-signal – but it is above all a statement of who one is. Odours define the individual and the group, as do sight, sound and the other senses; and smell, like them, mediates social interaction'* (Synott, 1991, p437).

Generally, odour perception is a primal sense that provides a sense of danger, navigation and location of resources. In today's society, it also provides an adequate warning for the onset of eye/airway irritation (Cometto-Muniz and Cain, 1995). The understanding that certain odours present a health risk has a strong influence on perception and how occupants may respond to the odour. As an example when natural gas leaks, it has a chemically infused smell that people recognize and understand as a risk (HSE 1996). With an increase of artificial odours/perfume used within our everyday lives, evaluating the need for additional odours within our indoor environment stimulates further debate regarding economical/social needs versus health impact.

Fragrances enter the body through the nose by inhalation, reacting with 20 million olfactory nerve cells equipped with dozen of hair receptors (Panda, 2003). The olfactory membrane is the only place in the human body that the central nervous system comes into direct contact with the environment and is processed through the limbic lobe, the oldest part of the brain and the area we connect with emotion (Panda, 2003). Each of the receptors recognizes several odours, and likewise a single odour could be recognized by several receptors (Hawkes and Doty, 2009). Humans have 350 functional olfactory receptor genes of approximately 1,000 non coded genes, compared to the 1,100 functional of 1,300 on coded found in mice (Young et al., 2002). Correlating to an evolutionary decline in sense of smell (Jones et al., 1992); although we do have the ability to distinguish a diversity of odours; approximately 10,000 scents (Hawkes and Doty, 2009); this is because of the retro nasal route in humans to increase sensation. Higher cognitive brain mechanisms and more olfactory brain regions enable humans to discriminate odours better than other mammals despite less olfactory receptor genes.

Odour perception is omnipresent in our indoor environment, but the interaction between odour and the occupants evaluation of the odour is complex; such as psychological responses to irritant stimulation, perceived odour quality, annoyance and symptom reporting (Berglund et al., 1999). The interaction is influenced by a number of personal factors including whether the smell is pleasant to unpleasant (Distel et al., 1990), beliefs about perceived health risks (Dalton, 2002), and environmental factors (Sucker, et al., 2001).

The size of the flavour and fragrance industry worldwide was estimated at £5.8 billion in 1994 (Somogyi, 1996) and has experienced an incredible growth to £9 billion in 2006 (Somogyi et al., 2007), with the United States, Western Europe, and Japan accounted for as much as 74% of the total consumption.

Marketing of products using aromas has also increased. In 1955 the classic Silver Cloud I Rolls-Royce car, tailored with red Wilton wool carpet and burl walnut for the doors and dashboard, the masterpiece of designer John Polwhele Blatchley was launched to the discernible buyer. For those fortunate enough to have purchased one of the 2,395 manufactured, the high quality of craftsmanship was the 'Spirit of Ecstasy'. However by the competitive mid-1990s, customers began complaining that the brand Rolls-Royce did not live up to their proceeding glamorous models (Lindstorm, 2005). Following reflective evaluation, Rolls-Royce used the 1965 Silver Cloud I model as a reference point to identify the different heady aromas associated with their brand. An olfactory analysis deconstructed the odours and found over eight hundred distinct elements, with expected ones like leather and mahogany but also unexpected matters such as underseal, oil and felt. Many of these products were no longer suitable for modern cars due to their safety implications and were replaced with products such as plastics and foams to recreate the look. Therefore Rolls-Royce decided to recreate the smell of traditional materials artificially and infuse into synthetic materials. The alluring scent of luxury became so successful; the manufacturers bottled their brand (Lindstorm, 2005). The new car smell is now a universal and familiar tactic of most car manufacturers and those companies who valet existing vehicles. Rolls Royce had inadvertently become the innovator behind scent marketing, whereby a customer becomes attracted to a product without consciously understanding the relationship of attraction and the influence that smell can skew their visual and audio senses.

A perfume consists of volatile chemical compounds that are sufficient enough in concentration to affect our olfactory perception. Their composition is usually complex; it involves numerous natural and synthetic sweet-smelling constituents, more than 5,000 of which are known (Groom, 1997) see appendix 9, page 418, as examples of principle chemicals in scented products**.** These products include beauty aids, household cleaners, scented candles and room sprays.

95% of the chemicals used in fragrances today are synthetic compounds derived from petroleum, (USHR, 1986) including benzene derivatives, aldehydes, and many other known toxins and sensitizers which are known toxins capable of causing allergic respiratory disorders (asthma), as well as neurological and cutaneous disorders. 84% of these ingredients have never been tested for human toxicity, or have been tested only minimally (Ashford and Miller, 1991). Espstein (1999) reinforces this message regarding the growth of chemical compounds and the lack of testing:

> *'Since 1965 more than 4 million distinct chemical compounds have been reported in the scientific literature; of these, 70,000 are in commercial production and have been completely untested or inadequately tested*' *with a spend of '£1 billion per year in 1940 to £400 billion in the 1980s'* (Epstien, 1999, p17).

Throughout history, humans have drawn fragrances from the natural environment for a variety of purposes, including use in religious and burial rituals, in aphrodisiacs, and to cover foul odours. In the late 1800's the first fragrance-containing synthesized ingredients were introduced. In 1868, English chemist William Perkin synthesised coumarin from the South American tonka bean to create a fragrance that smelled like freshly sown hay. Ferdinand Tiemann of the University of Berlin created synthetic violet and vanilla in 1882 (Aftel, 2004).

In 1889 in the United States, Francis Despard Dodge created citronellol, by experimenting with citronella oil, creating flora odours within different variations; this synthetic compound gives off the scents of sweet pea, lily of the valley, narcissus and hyacinth. Other synthetic perfumes included nitrobenzene, made from nitric acid and benzene, which is extremely carcinogenic; this synthetic mixture emits an almond smell and was often used to scent soaps (Muller and Lamparsky, 1991).

Linalool, (sweet, floral, woody and lavender aroma) the most abundant chemical, included in 60-80% of perfumed hygiene products and cleaning agents (Christensson et al., 2009) is known to cause lethargy, depression, and life-threatening respiratory effects. Studies show that fragrance chemicals can cause health effects, with some data suggests that as many as 75% of known asthmatics have asthma attacks that are triggered by perfumes (Shim and Williams, 1986). Many of the chemicals are nerve toxins with recognised effects on the central nervous system. Others weaken the immune system, leaving the user vulnerable to infection and disease. Fragrance chemicals also have the potential to effect and possibly damage brain tissue (Bridges, 2002). In 1989, the National Institute of Occupational Safety and Health recognised 884 substances (many synthetically derived from petrochemicals) from a list of 2,983 chemicals used in the fragrance industry which were capable of causing cancer, birth defects, central nervous system disorders, allergic respiratory reactions, skin and eye irritations (Griffin, 2003). Despite these ingredients that are known to cause asthma and even cancer, we are encouraged by powerful advertising to envelop ourselves every day with this pollutant.

Reviewing manufacturer's safety datasheets, acetone, often found in perfume, when inhaled can cause mild central nervous system disturbances such as dizziness, nausea, lack of coordination, slurred speech and drowsiness. Vapours can produce symptoms similar to those of indigestion; it can irritate the eyes, nose, throat, and skin. Alpha-pinene (pine-aroma) can be a moderate irritant to skin, eyes, and mucus membranes. Alpha-terpineol (lilac aroma) can cause excitement, loss of muscular coordination, hypothermia, central nervous system and respiratory depression and headache. Toluene was detected in every fragrance sample collected by the US Environmental Protection Agency for a report in 1991 (US EPA, 1991). Toluene not only triggers asthma attacks, it is known to cause asthma in previously healthy people.

According to ‘Air Currents’, publication of Allen and Handsbury's Respiratory Institute, division of Glaxo, (Allen and Hansbury, 1990) asthma has increased in the past decade by 31%, and in the same period asthma deaths have increased by 31%. Women and those over 65 years of age suffer the highest death rate for asthma. The reasons for increased risks are unclear and could include smoking, allergies, obesity, stress, environmental, genetic factors or a combination of all. Pre-existing conditions can also be affected by our environment with 72% of asthma patients in a study have adverse reactions to perfumes; i.e., pulmonary function tests dropping anywhere between 18% and 58% below baseline (Shim and Williams, 1986).

Several studies indicate that 15-30% of the general population reports some sensitivity to chemicals, including fragrances, and 4-5% report that chemical intolerance has a major impact on their quality of life:

- 28% "especially sensitive to chemical odours – sample size 809 (college students) (Bell et al, 1996),
- 34% with chemical sensitivity to chemical odours – sample size 192 (older adults) (Bell et al, 1994),
- 15% with chemical sensitivity to chemical odours – sample size 643 (young adults) (Bell et al, 1994),
- 32% with chemical sensitivities - sample size 3948 (office workers) (Wallace et al, 1993)

More than 80% report that exposure to fragrances is bothersome (Shim and Williams, 1986). The US EPA (1991) conducted a study into VOCs and included perfumes, identifying 150 chemicals in the 31 fragrances products.

> ‘*A few chemicals found in fragrances are known to cause cancer and birth defects: methylene chloride; toluene; methyl ethyl ketone; methyl isobutyl ketone; tert Butyl; sec Butyl; benzyl chloride.*

Other chemicals found in fragrances known to be neurotoxic: hexachlorophene; acetyl-ethyl-tetramethyl-tetralin; zinc-pyridinethione; 2,4, dinitro-3-methyl-6-tert-butylanisole; 1-Butanol; 2-butanol; tert-Butanol; Isobutanol; t-Butyl Toluene. Benzyl Acetate, Benzyl Alcohol, Benzaldehyde, Camphor, Ethanol xtr known to cause kidney damage in humans' (Kendall, 1997, p1).

Studies have shown that inhaling fragrances can also cause circulatory changes and electrical activity in the brain. These changes can trigger migraine headaches; affect the ability to concentrate, dizziness and fatigue (US EPA, 1991). Research suggests that perfumed products may contribute towards Attention Deficit Hyperactivity Disorder (ADHD) a behaviour problem in children (CDC, 2003); particularly the use of the plasticizer phthalates diethyl phthalate (DEP) or di-methyl phthalate (DMP), have been associated with numerous impacts on male reproductive health including changes in hormone levels and genital development in baby boys (CDC, 2003). DEP and DMP are used to help a scent to linger longer. In hair sprays, phthalates also avoid stiffness by allowing the spray to form a flexible film on the hair (CDC, 2003).

Sprays or aerosol cans used to dissipate microscopic substance particles into the atmosphere can also be inhaled into the deep recess of the lungs due to the size of the particles (Rodes and Wiener, 2001). Dr Daniel Perl, Director of Neuropathology at Mount Sinai Medical Centre in New York has found that aluminium in aerosol form may be more readily absorbed into the brain through the nasal passages. Studies show that regular use of these products, in particular deodorant aerosols can increase the risk of Alzheimer's by as much as 3 times *(*Graves et al., 1990).

A room containing an air freshener has high levels of p-dichlorobenzene (a carcinogen) and ethanol according to US EPA's 1991 study. Nazaroff and Weschler 2004 research concluded that mothers who used air fresheners daily suffered almost 10% more headaches than those who used them less than once a week. And that of the mothers who used air fresheners, 16% suffered from depression compared with 12.7% of those mothers who hardly ever used air fresheners.

Fragrance formulas are considered trade secrets; manufacturers only have to state fragrance on the label and do not need to identify the chemical makeup. Fragrance free or unscented does not guarantee they do not contain fragrance chemicals: they imply they have no perceptible odour. A product labelled unscented may contain a masking fragrance. If fragrance is added to a product to mask or cover up the odour of other ingredients, it is not required to be put on the label. A product must be marked without perfume to indicate that no fragrance has been added. Such labelling schemes result in confusion of consumers who might consider a product to be natural and scent free. In November 2013, the international fragrance association (IFRA) released a press statement applauding the adoption of the EU Commission's proposal on the protection against unlawful acquisition, use and disclosure of confidential business information referring to their perfume manufacturing members as law-abiding entrepreneurs who are put into a competitive disadvantage by having to reveal their creative secrets (IFRA, 2013a). Their submission to the EU focused on the economic impact that a weaken intellectual property protection of fragrances would endanger future job and wealth creation in the EU industry sectors (IFRA, 2013b).

There is no current proposal for the Government to review labeling on fragrance products. The 'push' effects of consumers would be required to drive such change. I have therefore included a discussion within Chapter 6, regarding the scent-marketing arena and the proposal of labeling and scent-free workplaces.

2.6.7 International Perspective

Understanding the Government's perception within a triple helix model is essential to determine recommendations to influence change. Application of IAQ in a global setting presents diverse challenges between developing and developed countries.

Developing Countries

There is considerable literature evaluating developing regions and the correlation of health associated with unvented burning of biomass fuel producing extremely polluted indoor air; resulting in severe health effects such as acute respiratory infections (ARI), chronic obstructive pulmonary disease (COPD) and lung cancer (Smith, 2003). The World Health Organization (WHO) has calculated that the burning of solid fuel for cooking and heating in developing countries might be responsible for nearly 4% of the global burden of disease, approaching 2 million premature deaths per year (Smith, 2003).

Researching the WHO's databases on indoor air quality, the University of California at Berkeley have collated indoor air pollution published literature from over 250 communities globally using research from 1968 to 2003 (WHO, 2012) which focused on developing countries. Extracting the data I have illustrated, with two graphs, research conducted by year and by country as below, figures 3 and 4.

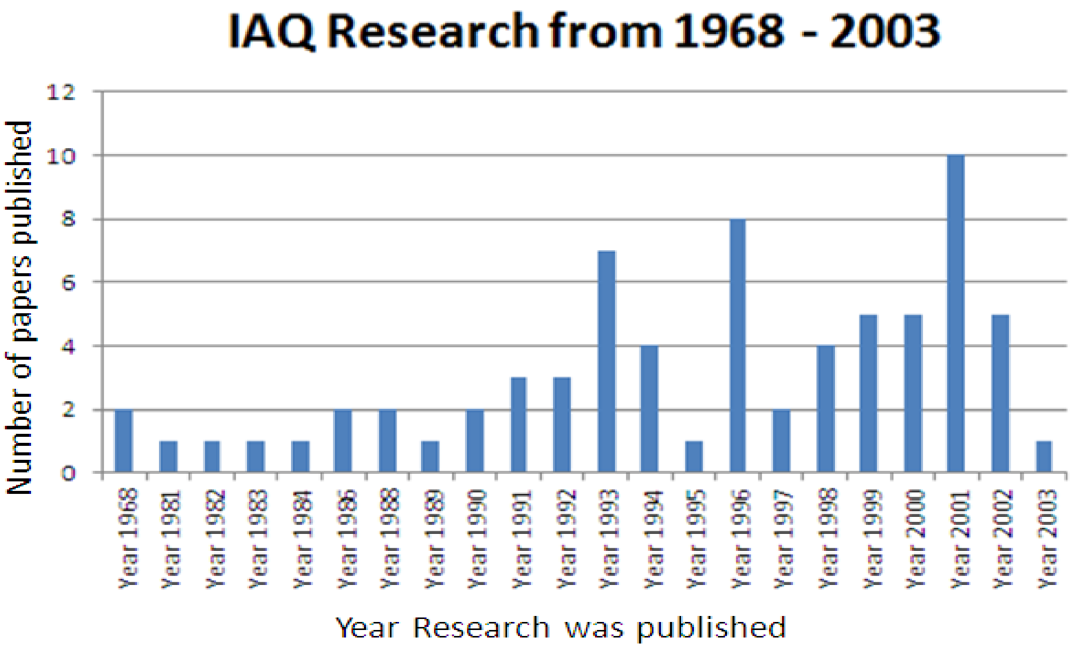

Figure 3: IAQ Research from 1968-2003 by Year (WHO, 2012)

University of California at Berkeley collated indoor air pollution published literature from 250 communities during 1968-2003.

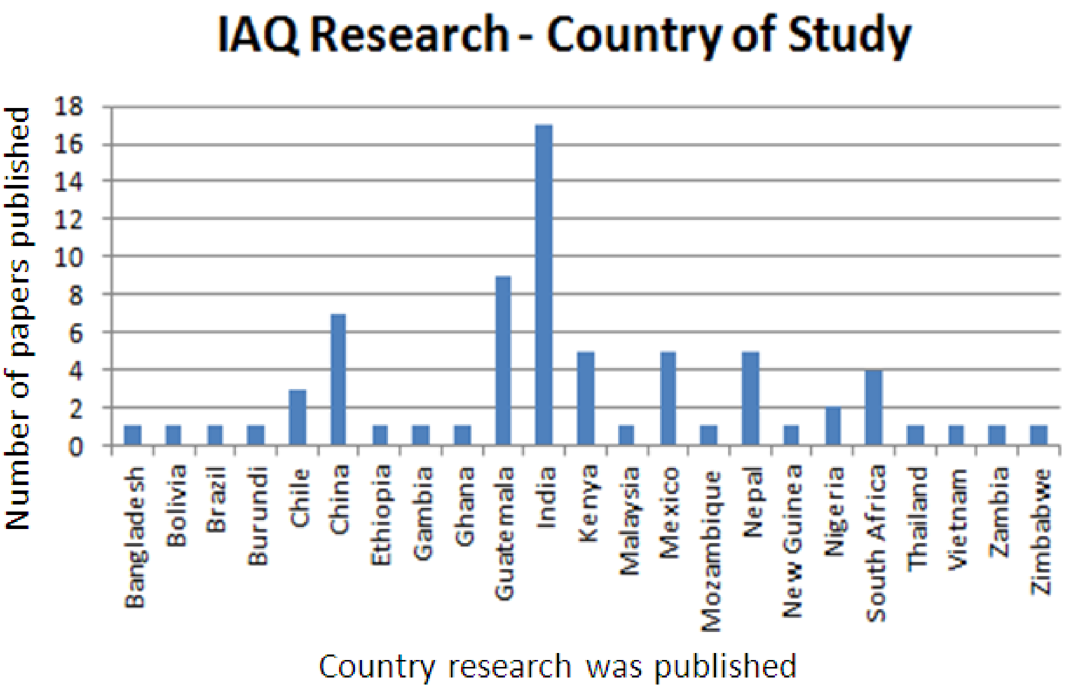

Figure 4: IAQ Research from 1968-2003 by Country (WHO, 2012).

University of California at Berkeley collated indoor air pollution published literature from 250 communities during 1968-2003.

Within figure 3, globally we begin to see IAQ activities increase from 1993 through to 2002, although there are no particular trends in type of research other than burning of biomass fuels. All research focused on the impact of lungs and respiratory diseases, with none addressing broader issues, with discussions around contributing causes of particulate matter or biomass fuels, and this was regardless of whether the research was in developing or developed sections of society; such as the air pollution in native huts in the highlands of New Guinea (Cleary and Blackburn, 1968), extensive research in India for biomass fuels, table 4, to indoor air pollution and respiratory health in urban and rural China (Venners et al., 2001).

In 2000, 191 nations signed the declaration of The United Nations Millennium Development Goals; which are eight goals that focus on combating poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women by 2015. Within the goals, there are references to indoor air pollution:

- *With less time spent on fuel collection, people will have more time available for education and income generation activities that are likely to contribute to eradicating extreme poverty (Goal 1).*
- *The collection of fuel imposes a serious time burden on women and children and alleviating this drudgery will contribute to promoting gender equality and empowering women (Goal 3).*
- *As most of the disease burden due to indoor air pollution falls on children under five years of age, interventions will help achieve a significant reduction in child mortality (Goal 4).*
- *The proportion of the population relying on solid fuels constitutes one of the indicators to monitor progress towards ensuring environmental sustainability (Goal 7)*

(WHO, 2012, p1)

The discussions from the declarations centre around indoor air quality again relate to the burning of solid fuels, there is no dialogue regarding the impact of other types of pollutions, such as chemicals, or changes to ventilation. The challenge to reduce the use of solid fuels that are harmful to the environment are accompanied with associated society concerns, such as the association between use of such fuels and poverty which can also draw correlation with education, gender equality and health (WHO, 2011). Indoor air quality seemed to have been used as a poverty indicator rather than a specific concern. It is, of course naive to consider indoor air pollution is a significant contributor to poor health as such poverty incurs parallel concerns, such as inadequate diet (Reutlinger and Selowsky, 1976), lack of access to medical support (Peters, et al., 2008) and poor housing (Pugh, 1997).

However, I do find the concept of burning fuels used by WHO as an indicator intriguing; has the visual sight of smoke and the accompanying burning odour generated the awareness of indoor air quality in developing countries. Would a less malodorous contaminant provoke the same response?

The historical experience from the developed regions, in particular the industrial ages has cultivated our understanding of venting rooms, the vented stove is an instilled solution. Although conversely as developed countries reduce the risk by adapting to other fuel types (such as gas and electricity) and vent solid fuel gases; the risk has been replaced by alternative risks.

Developed Countries

In developed regions, buildings have central heating, an extensive range of building materials and furnishing/products and a low rate of ventilation which has resulted in a high prevalence of lung cancer, allergies, other hypersensitivity reactions including sick building syndrome (SBS), and multiple chemical sensitivity (MCS), and acute respiratory infections (ARI) (Sundell, 1999).

Despite our knowledge regarding the impact of our indoor environment, as discussed on page 43 commencing with the book of Leviticus, and our drivers to improve the environment, Philanthropist Reverend Stephen Hales page 48 it was the World Health Organization (WHO, 1983), who first recognised Sick Building Syndrome (SBS) but had difficulty describing a collection of symptoms with no direct cause; with an excess of irritations of the skin and mucus membranes, headache, fatigue and difficulty concentrating, their study focused on workers in modern office buildings. The WHO's viewpoint is restricted, as it fails to acknowledged type of buildings, SBS is not discriminating to new buildings only.

In the last several years, a growing body of scientific evidence has indicated that the air within buildings can be more seriously polluted than the outdoor air in even the largest and most industrialised cities. According to the US Environmental Protection Agency (2001), concentrations of Volatile Organic Compounds (VOCs) are consistently up to 10 times higher indoors than outdoors. The WHO reported that 30% of new and refurbished buildings (with re-circulated ventilation or air conditioning systems) have an excess of illness amongst staff and that up to 85% of staff in such buildings suffer from some form of illness (WHO 1983 and 1986). The WHO described these unidentified symptoms as sick building syndrome (SBS) (WHO, 1983). Finnegan et al. (1984) early research defined the term SBS where:

> '*complaints of ill health are more common than might reasonably be expected'* (Finnegan et al. 1984, p1573).

Finnegan et al. (1984) conducted nine case studies to identify six significant symptoms during a time when SBS was considered insignificant:

'*Although the symptoms of the sick building syndrome do not represent a disease but rather a reaction to the working environment, the scale of the problem is probably considerable, and the high degree of dissatisfaction seen in this study demands attention from architects, engineers, and the medical profession'* (Finnegan et al. 1984, p1575).

The US Environmental Protection Agency provided further clarification in 1991 describing:

'A situation in which reported symptoms among a population of building occupants can be temporally associated with their presence in that building' (US EPA, 1991, p17).

There is no universal agreed definition of SBS. The debate to provide a concise definition of indoor air quality and specifically what constitutes acceptable indoor air quality continues. However the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) provide a more specific explanation describing a building in which a significant number (more than 20 per cent) of building occupants report an illness (ASHRAE, 1998). The individuals who suffer from SBS report that the symptoms occur when they spend time indoors, particularly in office buildings, and that the symptoms lessen while away from the building (Levin, 1989) and (Mendell, 1993). Despite the variance in descriptions, the contributors of suggested definitions all agree that the build-up of pollutants from insufficient ventilation is a major causative factor of SBS, attributed by our environmental consciousness to reduce natural ventilation as we strive for energy conservation.

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), founded in 1894, are a building technology society with more than 50,000 members worldwide.

They are an active contributor to the IAQ agenda. Their sphere manages the research, standards and publications of heating, ventilating, air conditioning (HVAC) and refrigeration. ASHRAE have played a predominate role in developing standards for IAQ and contributing towards the global debate, publishing their first standards for ventilation that considered IAQ requirements (ANSI/ASHRAE,1973). Although not a building standard, it was adopted by the American National Standards Institute (ANSI) as ANSI B 194.1-1977.

The standard has been continuously updated in 1981, 1999, 2001, 2004, 2007 and 2010 with consideration for smoking and non-smoking airflow rates and the definition of allowing two different methods to comply with the standard, the ventilation rate procedure and the indoor air quality (IAQ) procedure. Acceptable indoor air quality is a partially subjective concept defined in the standard as:

> *'Air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction'* (ASHRAE, 2007 p3).

ASHRAE (1989) published a position paper on indoor air quality (IAQ) asserting the importance of IAQ as a public health issue. Since 1989, several standards and guidance has been issued allowing for an accrued knowledge disseminated to their members. ASHRAE's (2010) recent IAQ guidebook provides a cross-functional approach discussing best practice, strategies for managing IAQ, building designs, commissioning and construction. Throughout the guide, there is a strong focus on ventilation as a solution to IAQ. Although this guide is a purchased product, many of their standards and guides are freely accessible via their internet pages. The approach to providing free resources and standards has emphasized their sincere approach to IAQ and their responsibility to communicate to their communities.

Much of ASHRAE's past research and standards development in IAQ has been North American-centric. However, Direction 4 of the ASHRAE Strategic Plan commits ASHRAE to be a global leader in the HVAC and research community (ASHRAE, 2006). Despite their vision, the limitations of their organisation to engage in health-oriented aspects of IAQ has been recognized, they attribute their limitations to their position within the HVAC industry, debating whether IAQ sits comfortably within their remit and identifying the lack of funding to expand their interests (ASHRAE, 2011).

ASHRAE also criticises the Government, professional bodies and the industry's lack of support resulting in gaps within research and practical application, particularly concerning the motivation of engagement:

> *'Industry supports research on IAQ product development, but has less incentive to support IAQ research unrelated to the development of marketable products'* (ASHRAE, 2011, p10).

As ASHRAE reposition their organisation within the IAQ agenda, they recognise the increased activities around an integrated approach of IAQ and energy conservation, linking high performing buildings that are both energy efficient and have good IAQ (ASHRAE, 2011).

> *'The complex relationship between IAQ and external environmental conditions, coupled with the effects of climate change, necessitates a paradigm shift towards creating buildings that are not only comfortable and healthy for the occupants but are also sustainable'* (ASHRAE, 2011, p7).

As we become more aware of our environmental obligations to protect our energy resources and perhaps our pockets, the challenges of the economy generates interest in renewable and sustainable energy and the practice of energy conservation. This has resulted in energy efficient air tight buildings with mechanical systems controlling air flow to insulate against energy loss.

During the past forty-five years, more soft furnishings and carpets were being used within buildings, resulting in a greater emission of a variety of chemicals into the indoor environment. At the beginning of the 20th Century around 50 materials were used in buildings; there are now around 55,000 building materials available and over half are manmade (Roalkvam, 1997). Such contaminants within the workplace and home can crescendo to an unacceptable cocktail of emissions.

Many modern synthetic materials and some traditional materials can be deleterious to indoor air quality. Risks can be posed during and directly after application of the material, when concentrations of associated pollutants are highest over a prolonged period of time. As is the case with many chemicals found in the indoor environment there is often scientific uncertainty over the risk posed to humans. This is due to the large number of chemicals currently present in the indoor environment, of the 75,000 chemicals in common commercial use, only 3% have been tested for carcinogens (Steingraber, 1997). The Toxic Substances Strategy Committee stated that the majority of cancers (80-90%) are triggered by exposure to substances in the environment (Landrigan et al., 2002).

With hundreds of varied compounds, typical immediate health effects can include eye, nose and throat irritation, headaches, migraines, nausea, fatigue and the feeling of dizziness, see appendix 1, page 391. Such immediate effects are usually short-term and treatable. Sometimes the treatment is simply eliminating the person's exposure to the source of the pollution, if it can be identified. Reaction to indoor air pollutants can be individually determined by factors such as gender, age, activity within exposed area, individual sensitivity, repetitive exposure and/or pre-existing conditions. Other health effects may show up years after exposure has occurred or only after long or repeated periods of exposure. These effects, which include some respiratory diseases, heart disease and cancer, can be severely debilitating or fatal. The US Environmental Protection Agency recognises indoor air quality as one of the top five health hazards (US EPA, 2001).

Allergies are also rapidly increasing worldwide, but more extensively in the developed than in the developing world and are strongly associated with exposures in indoor air (Sundell, 2004); interest has been directed towards the exploration in understanding which indoor exposures can be associated with this increase in morbidity.

With the exception of the WHO's activities appraising the impact of indoor air quality within developing countries and the collation of research from developing countries by the University of California at Berkeley, there is limited global collaboration to gather data regarding indoor air quality. This becomes more apparent whilst reviewing developed countries' research. Often papers have a specific contaminant focus, in particular smoke free environments, or a definite location, such as office, schools, residential.

In 1978, the first International Indoor Climate Symposium was organized, with ten researchers from the USA, Slovakia, Sweden, and Denmark gathered to review the status of indoor environmental research (Fanger et al., 1979). The symposium was closely followed by a report on indoor air pollutants by National Research Council (Clausen et al., 1981). Recommendations from the National Research Council's report discussed the structure to supporting research and introducing standards for study design and quality. It further made recommendations that research would needed to be collated and integrated, with a focus on dissemination. The report listed key areas of concern that required further research; radon, formaldehyde, tobacco smoke, asbestos, gas combustion, consumer products allergens, ventilation standards and quality of exposure studies. The report concluded with the need to educate society.

> *'People informed about the potential for exposure to pollutants, from consumer products, tobacco smoke, combustion products, etc., will exercise some control to reduce the pollutant concentrations in their environments'* (Clausen et al., 1981, p56).

The National Research Council encouraged the active participation of professional and trade associations to develop standards and disseminate information. These are significant statements and to some extent awareness around tobacco, combustion and asbestos has been achieved, although sentience does not always lead to individuals changing habits, such as smoking. The dissemination is isolated and led by silo organisations and projects, there is little evidence of a clear IAQ identity and aside from a few global IAQ organisations, research and resources are not collated, country objectives are limited and transformational activities to influence change are negligible.

In 2010 ten researchers from the USA, Slovakia, Sweden, and Denmark gathered again to discuss the development of IAQ, with a clear agenda to understand what has been learnt from 1978 and what should shape the future of IAQ. Below I have summarized the key questions with the reports summary answers (Clausen et al. 2011): The discussions were structured around the following five questions:

What are the most important research findings since the first Indoor Environmental Quality (IEQ) conference in 1978?

- Exposure to environmental tobacco smoke (ETS) can produce adverse health effects;
- Low ventilation rates can result in adverse health effects;
- Emissions from biomass cook stoves are a major contributor to ill health in developing countries;
- Sick building syndrome (SBS) symptoms are real, not just psychosomatic;
- In addition to human bio effluents, indoor activities, materials and products can adversely affect IEQ;
- Important infectious diseases can be transmitted by airborne routes indoors;
- Indoor chemistry influences indoor environmental quality and health;

- Exposure to particles of outdoor origin is associated with increased morbidity and mortality.

What are the most important research questions in our field from an academic point of view?

- How can we ensure that IEQ goals are met as energy consumption to operate buildings is reduced?
- How much exposure to which chemicals and by which pathways occurs indoors?
- What are the health effects of pollutants from indoor sources?
- What are the health consequences of pollutant body burdens?
- How can measurement methods for field studies of IEQ be improved?
- How can air cleaning, as an IEQ control technology, be improved?
- What constitutes good IEQ?

What does society believe are the most important research questions in our field?

- Is this product safe?
- How can I protect my family from infectious diseases?
- Is my indoor air safe?

Are there topics for which we can say, 'No more research is needed?

- Photocatalytic oxidation;
- Volatile organic compounds (VOCs);
- Indoor–outdoor pollutant relationships;
- Bio-aerosol sampling using culture-based techniques;
- Effects of houseplants on indoor air quality.

  (Clausen et al. 2011)

The report discussed the changing landscape of IAQ and questioned the future role and visibility of the IAQ. They considered the synergy between the green building development and the voluntary certificate of such developments; the criteria for energy certification of buildings and potential integration into the building codes; and finally the role of environmental health, environmental science, environmental exposure, environmental epidemiology, air quality engineering, building science, and architectural societies and their establish objectives and disciplines, emphasising the difficulties in establishing a multi-disciplinary, collective approach stating:

> *'The existence of these societies also poses challenges toward establishing a strong international IEQ society. Such a society must be multidisciplinary; but as most of the experts also are active in their respective international and national environmental or architectural communities, their available time and interest in being active in an IEQ society may be limited' (*Clausen et al., 2011, p228).

Despite recognising this conflict, no discussions or recommendations were offered. Furthermore the authors recognised the restrictions in their paper and controversially, without reservation concluded with their closing statement:

> '*There you have it – our (very probably) biased views on the status of indoor environmental research! If you have made it to these closing remarks, it may be that you disagree with us about some of these points, and you may even have been offended by our choices. We apologize for the offense, but encourage you to share your views with our community'* (Clausen et al. 2011, p228).

Following 22 years of a changing and dynamic industry they had sought no engagement with a broader community, reflecting:

> '*All of the researchers participating in the discussion were men, mostly of a greying age and mostly from countries with advanced economies. Did this composition cause us to overlook important issues for developing regions, women or for younger researchers?*' (Clausen et al. 2011, p222).

The report was frustrating, lacking depth and an understanding of the real issues facing a changing world. There were no details regarding influences, challenges and barriers for education and policy and implementation of change management. The paper was purely academic and considered no transformational activities. During my literature review I had considered rejecting this paper due to lack of value; however my decision to include it is based on the frustration that such a committee could demonstrate leadership and reposition IAQ; but failed to contribute to the agenda. With such prominent stakeholders as authors within the IAQ arena, the lack of leadership demonstrates the gap between academia and practical application. This is a continuous trend I have observed.

Globally the US are dominant within the arena of IAQ, this is driven by the efforts of ASHRAE and ISIAQ, particularly with regards to setting standards and freely disseminating information/guidance. Within the global literature review, they are the most prominent authors who have considered the discussions around implementation of IAQ.

They have also considered the importance of IAQ as a significant subject matter, unlike the goals of WHO where IAQ is becoming lost in developing subjects, such as environmental degradation, gender and disease. The risk of losing a strong agenda of IAQ could possibly threaten its visibility and ownership.

2.6.8 The perception of a European IAQ agenda

In 1987 the World Health Organization Regional Office for Europe published the first edition of Air quality guidelines for Europe (WHO, 1987a), containing health risk assessments of 28 chemical air contaminants. In 2000, this list was extended to 35 pollutants (WHO, 2000). The publication has been recently updated in 2010 with the aim of providing a basis for protecting public health from adverse effects of air pollutants and to eliminate or reduce exposure to those pollutants that are known or likely to be hazardous to human health or wellbeing. The guidelines are intended to provide background information and guidance to international and local authorities in making risk assessment and risk management decisions (WHO, 2010).

> '*Under the principle of accountability, all relevant organisations should establish explicit criteria for evaluating and assessing building air quality and its impact on the health of the population and on the environment'*. (WHO, 2010 p2)

WHO have clearly stated the need for organisations to adopt a proactive strategy for monitoring occupancy impact against key criteria of contaminants. Table 4, page 88, provides a list of pollutants considered within the WHO's comprehensive Indoor Air Quality Guidelines for 2010.

Table 4: Extracted from WHO (2010, p3).

Pollutants considered for inclusion in the WHO indoor air quality guidelines

Group 1. -Development of guidelines recommended	Group 2. -Current evidence uncertain or not sufficient for guidelines
• Benzene • Carbon monoxide • Formaldehyde • Naphthalene • Nitrogen dioxide • Particulate matter (PM2.5 and PM10) • Polycyclic aromatic hydrocarbons, especially • Benzo(*a*)pyrene • Radon • Trichloroethylene • Tetrachloroethylene	• Acetaldehyde • Asbestos • Biocides, pesticides • Flame retardants • Glycol ethers • Hexane • Nitric oxide • Ozone • Phthalates • Styrene • Toluene • Xylenes

In order to address the concerns of IAQ raised by the WHO, the Commission of the European Communities introduced the European Environment and Health Strategy in June 2003 (COM, 2003). The Strategy intended objectives were to reduce the disease burden caused by environmental factors in the EU, to identify and to prevent new health threats caused by environmental factors and to strengthen EU capacity for policymaking in this area. The Strategy was followed up by the European Environment and Health Action Plan 2004-2010 (COM, 2004) with the view to drive a coordinated approach to monitoring and managing the interaction between health and the environment.

The Action Plan identified 13 actions with three main themes:

- Improve the information chain by developing integrated environment and health information to understand the links between sources of pollutants and health effects;
- Fill the knowledge gap by strengthening research on environment and health and identifying emerging issues;

- Review policies and improve communication by developing understanding, risk communication, training and education to give citizens the information they need to make better health choices, and to make sure that professionals in each field are alert to environment and health interactions.

The Commission also proposed bio-monitoring to explore the impact of the environment on health with the view to translate these results into policy action. Within the action plan, the Commission proposed to develop work on improving indoor air quality, Action 12. The initial focus of this action centred on addressing environmental tobacco smoke, in particular the restriction of smoking in all workplaces. The Commission also discussed developing networks and guidelines on other factors affecting indoor air quality including dampness/mould, building materials, indoor effects of outdoor emissions and their health implications. However they failed to address the broader concern of products, such as furnishing, and synthetic materials, such as scents, within the scope of their concern.

In 2004 the European Commission conducted a survey across the 25 member states to understand the attitudes of European citizens towards the environment. No demographics or methodology was provided by the survey other than approximately 1,000 people per country responded (with Malta returning the smallest sample size of 500 respondents). 60% of the members expressed concerns regarding the impact of the environment on their health, in particular 52% believed air quality was the greatest concern and purported that the European Union was not doing enough to drive environmental protection incentives (EC, 2005). In the 2011 EC survey, this figure had increased, 72% felt the EU were not doing enough about the problem (EC 2011). I have discussed this paper further on page 226 when comparing results from my surveys within my project activities.

In May 2005 the Commission mandated the Scientific Committee on Health and Environmental Risks (SCHER), an independent scientific committee, to deliver an opinion on a possible risk assessment strategy to support policy on the indoor air issues; to identify potential areas of concern in relation to the different pollutants and to consider risks associated with the use of air fresheners. The SCHER concluded that:

> *'Data specifically addressing emissions from air fresheners and the consequent exposure identification is sparse and insufficient for a comprehensive risk assessment'* (SCHER, 2005, p4).

The report had limited impact and made no recommendations, other than requesting further data. In 2007 SCHER reported on their challenge to devise a risk assessment strategy to support the Committee's Policy on IAQ, which included identifying competency gaps in current research and reviewing specific concerns such as air fresheners. The reported commented on the extensive gaps in data and the complexities of applying a risk assessment model, stating:

> *'Taking into account all the variability and complexity in the indoor environment, the data for risk assessment are scarce and often insufficient'* (SCHER, 2007, p14).

The SCHER report recommended the development of health based guideline values for key pollutants and introducing evidence based risk assessments tools with the view to increase risk assessment activities.

Frustratingly SCHER and the Commission should focus their attention on a strategic framework to structure the development of knowledge sharing and implementation of IAQ management, as opposed to specific IAQ concerns.

A broad focus would enable a wide range of IAQ topics to be discussed, triangulated and controlled; it would also facilitate the ability to encapsulate new IAQ topics.

The EC commissioned a Mid Term Review of the European Environment and Health Action Plan 2004-2010 in 2007 which satisfied the smoke free working environment objectives, but expressed a concern regarding the insufficient funding for human bio-monitoring and resources to measures impact of indoor air quality (COM, 2007).

Despite the lack of resources, localised initiatives had been implemented, including the AIRMEX project (European Indoor Air Monitoring and Exposure Assessment Project) coordinated by the Joint Research Centre. This project started in 2003 and was aimed at identifying and quantifying the main air pollutants and their sources present in public buildings, schools and kindergartens in 11 European cities, but did not include the UK. An exposure assessment investigating indoor air quality and personal exposure concentration by measuring 19 volatile organic compounds in indoor air, such as carbonyls, terpenoids and aromatics were conducted. The findings presented values of outdoor air, indoor air and a combination of both which resulted in exceeding the exposure limits of selected pollutants; thus indicating that ambient monitoring is not a realistic methodology when assessing personal exposure from our environment; and as established occupational hygienic monitoring by use of dosimeters provides more accurate data, IAQ sampling should be considered within a similar approach.. This study also raises a debate regarding body burden which I have explored further in chapter 6, page 271.

The EU Environment and Health Action Plan - EHAP succeeded to create a number of preconditions necessary to close the knowledge gaps in order to prepare the launch of a coordinated approach for the next action phase. The Commission had also created an expert group in 2006 to coordinate work across policy areas.

The report indicated ten key achievements, including the identification of key pollutants and focus group studies identifying vulnerable populations. The report had also indicated a stronger alliance between member states. But many of their claimed achievements were misrepresented within the report. As an example, key achievement 4 discussed creating a tool to develop a website for disseminating IAQ information. This website has not been developed and is still under review; therefore it is somewhat ambitious to claim a success. Achievement 5 discussed creating an ad-hoc working group to debate labelling schemes within Europe; again this has not been achieved. Although claimed a success by the EU, this project has stalled and failed to deliver, which is mainly due to the lack of a coordinated approach and silo projects. The report concluded that the next phase was to put all these efforts into a policy coordinated framework based on health and focussing on the priority diseases identified by the 2003 European environment and health strategy. In 2010, the Commission reported an update of the strategy:

> 'O*ne important achievement since 2004 is a strengthened cooperation between stakeholders on Indoor air quality'* (COM, 2010, p14).

This comment is a direct reference to the collaboration with WHO that had developed IAQ guidelines for several pollutants. To date, this has received low visibility within the UK and has failed to be interpreted by OHS practitioners and enforcement agencies. Standards of indoor air quality within Europe are not a standalone issue. The Commission should regard IAQ as part of a broader picture in connection with legislation on health, housing, spatial planning, energy and sustainability**.** De Brouwere et al., (2007) recognised the complexity of introducing standards by discuss indoor air quality as

> '*Too comprehensive to tackle by any legal construction'*
> (De Brouwere et al., 2007, p3).

Furthermore De Brouwere et al., (2007) suggested that EU members should adopt a risk management approach by setting standards and introducing air quality policies. Such approach should include efficient controlling and monitoring to test if policies are successful, thus testing the credibility of policy decisions. I would further suggest that tools and resources should be provided to enable countries to translate and implement standards.

Legislation is only useful when implemented and enforced, e.g. when accompanied by an operating monitoring activity. Although exposure limits are set for specific contaminants and air quality levels, currently none of the EU directives prescribes explicitly a monitoring and control programme for indoor air quality and no EU members systematically integrate indoor air monitoring systems within their guidelines. There are numerous examples of sporadic, independent monitoring in several EU countries, ranging from complaint-based interventions in Belgium and Poland, to standardised measurement campaigns in schools in France or survey based monitoring schemes in Germany. In Italy, the necessary facilities for a control programme are being set up, and in Sweden a national register has been implemented to monitor the effectiveness of the Energy Directive (De Brouwere et al., 2007).

Some EU members conducted project based monitoring, such as Hungary's monitoring activities following the smoking ban (McNeil et al., 2012); and Sweden monitoring the effectiveness of ventilation rates since 1999 (Liddament, 2010), revealing that the actual ventilation was not in compliance with the original building design, with 80% not meeting minimum ventilation requirements, which shows the importance of control programmes. Systematic monitoring and control programmes are lacking in the EU, consequently assessment protocols in the UK have not been implemented.

Studies on exposures of indoor environments and health effects in developed countries have been conducted mainly in North America and northern Europe. However we are beginning to see examples from the former eastern European countries with relatively modern building constructions and building materials, but with a high ventilation rate (due to the low price of energy and leaky building constructions), resulting in a relatively low prevalence of allergies (Bjorksten, 1996), (Bonnefoy et al., 2003) and (Sundell, 2004). The implementation of energy conserving strategies in the built form must be balanced with occupant health needs.

In 2007 a three year Health Air project commenced with the view to develop activities and education to improve knowledge and resources of IAQ, particularly in construction projects, thus targeting the source of pollution. The team consisted of representation from the Netherlands, France, Denmark, Prague and the UK. The project was divided into three areas:

- *'Step 1: A State of the art review of the facts and problems related to IAQ from three points of view: the human, the indoor air of the space and the sources contributing to indoor air pollution;*
- *Step 2: Information exchange in the form of a workshop, interviews and a forum with management and uses of the built environments;*
- *Step 3: Actions and methods to improve IAQ ranging from education to regulation and research opportunities.*
  (Bluyssen et al., 2010, p4).

'*Even though almost all acknowledged the importance of IAQ in relation to health and comfort, most do not have a good technical knowledge as to why it is important*' (Bluyssen et al., 2010, p12).

Bluyssen et al., (2010) acknowledged the request from the end-users to provide tools that can translate theory into action; this included the recommendation to explore how to translate technical findings into simple terms. Bluyssen et al., (2010) summarised a parallel findings from my own research:

> *'The stakeholders (e.g. architects, product producers and building owners) who can potentially do something to improve IAQ will not, because their clients are not requiring them to act and ultimately the public would not know what to ask for'. (*Bluyssen et al, 2010, p14)

Bluyssen et al., (2010) is an encouraging read and has demonstrated the understanding of an interdisciplinary approach and the need to drive a pull (as opposed to a push) from society to integrate sustainable change. Notwithstanding the plethora of research discussing the health concerns of indoor environments, there are few current standards and guidelines and various governmental and private-sector agencies within the EU that directly or indirectly address the issue of indoor air quality; there is also an absence of any holistic framework in the workplace setting, lack of direction and leadership by the EU and limited motivation by Government bodies.

2.6.9 Through the lens of a UK outlook

The historical and global context provides an understanding of the evolution of IAQ which has remained a token focus in UK over the last four decades; during this period changing conditions within indoor environments have reduce ventilation and increase the opportunity for an accumulation of undesirable levels of indoor air pollutants.

There have been limited epidemiological studies of the direct impact of IAQ, other than short term, acute effects; it is difficult to assess the long term latent effects and their association with IAQ. Nevertheless in 2004 around 15% of people in England had asthma, positioning the UK as the highest prevalence of asthma symptoms in the world (Howieson, 2005). Although, as previously discussed on page 70, not all asthmas are caused by the environment, nonetheless when one reviews the top countries for asthma in the world, in hierarchy order, the shocking figures of the UK is evident:

1. Scotland;
2. Jersey;
3. Guernsey;
4. Wales;
5. Isle of Man;
6. England;
7. New Zealand;
8. Australia;
9. Republic of Ireland;
10. Canada;
11. Peru;
12. Trinidad/Tobago;
13. Costa Rica;
14. Brazil;
15. United States. Braman (2006).

The Asthma UK charity (2011), seven years later, still reports the UK as having the highest prevalence of asthma.

> *'There is, undoubtedly, a genetic component to asthma, and it seems possible that changing patterns of environmental influences, such as exposure to microorganisms, pollutants, indoor and outdoor allergens, and diet, exert a strong influence on the development of the disease in susceptible individuals' (*Braman, 2006, p75).

The complexities of understanding the impact of the various contributing components is limited and often considered within silo research, as opposed to combined factor influence, which creates a difficulty in discussing IAQ impact with authority. The UK has also incurred the sick building effect, with the HSE claiming 30–50 per cent of new and refurbished buildings could be classified as 'sick' (HSE, 1992); and as the carbon footprint demands for buildings to become more efficient increases, the problem associated with poor indoor air quality will continue. Yet despite these findings, there is a limited awareness regarding indoor air quality within the UK; which stimulates a discussion to understand why and to probe the risk perception of IAQ compared to alternative risk priorities.

There are numerous organisations that are in charge of different aspects of indoor air quality; of which the sources of information and the interaction between the agencies are disparate, as presented in Table 2, page 28, such as:

- Department of Health (Committee on the Medical Effects of Air Pollutants (COMEAP) and bio-monitoring);
- Health & Safety Executive (health and safety);
- Local authorities (health, safety, environment and housing,);
- Department of Business Enterprise and Regulatory Reform (BERR) (product);

- The Department for Environment, Food and Rural Affairs (DEFRA) (policy makers for the environment);
- Environment Agency (external air quality);
- The Health Protection Agency (HPA) (health and well-being of the population).
- British Occupational Hygiene Society (membership for occupational hygienists);
- Institution of Occupational Safety and Health (membership for OHS practitioners);
- British Institute of Facilities Management (membership for facility managers);
- The Royal Institute of British Architects(RIBA) (membership for architects);
- The Federation of European Heating, Ventilation and Air-Conditioning Associations (REHVA) membership for HVAC engineers);
- The Chartered Institute of Environmental Health (CIEH) (public health campaigners and membership).

Despite these resources, the management and development of indoor air quality is not prioritised or strategically driven by these organisations as an important factor in risk management or the comfort and health of workplace occupants. There is a clear need to address indoor air quality more seriously and effectively, which should include a coordinated approach by the various organisations. A UK regulatory framework is also absent which could provide guidelines for a range of parameters using best practice standards from International and European research. Regardless of such research directed to improving the quality of outdoor air, the UK only briefly discussed the requirements for indoor air quality guidelines in 1991, by the House of Commons Environment Committee (1991). In its report on indoor pollution, it recommended that the Government develop guidelines and codes of practice for indoor air quality in buildings, which specifically identify exposure limits for an extended list of pollutants.

The Department of Health Committee on Medical Effects of Air Pollutants released guidelines for manufacturers, architects and engineers involved with building design and services, to assist in the process of reducing poor air quality (Department of Health, 2004). Although this has been an encouraging step, there is no method of enforcement. The guidelines are perceived as performance criteria, which contain some guidelines, but these are not mandatory. There is also no evidence that these have been widely disseminated. Indoor air quality was excluded from the Department of the Environment, Food and Rural Affairs Air Quality Strategy (DEFRA, 2007). Building Regulations F (Department for Communities and Local Government, 2006) consolidate energy efficiency, requiring further ventilation designs to be incorporated within airtight buildings, with no balance regarding occupant requirements. The Health, Safety and Welfare Regulations 1992 (HMSO, 1992) cover a basic requirement for thermal comfort, governing a minimum working temperature of 16 °C or 13 °C if physical effort is required. However, there are no maximum working temperatures, no details regarding humidity, carbon dioxide levels or other associated air contaminants. The Health & Safety Executive have developed guidance for thermal comfort and heat stress in the workplace (HSE, 2008), but offer no further guidance for indoor air quality standards.

The British Occupational Hygiene Society discusses health hazards associated with dust, chemicals and biological compounds with regards to Control of Substances Hazardous to Health Regulations 2002 occupational exposure limits (HMSO, 2002), but do not incorporate indoor air quality models as a competence skill within their professional certificates (BOHS, 2008). The British Institute of Facility Management (BIFM) who provides information, education, training and networking services for over 12,000 members do not offer any indoor air quality training programmes or in-depth discussions regarding IAQ even though HVAC maintenance and installation literature features within their magazine and website content. Any associated programmes are related to energy management and sustainability rather than occupancy health and wellbeing.

Even within the Facilities Managers Guide to Auditing the Indoor Environment (BIFM, 2003) the literature focuses on microbiological hazards, with limited discussions around VOCs, temperature, humidity and carbon dioxide.

Occupational health programmes relating to air quality are often associated with topics such as lead, silica, solvents and so forth, generated from industrial processes. Such topics receive high agenda visibility and have an explicit knowledge implementation. Although less traditional topics, such as the model of indoor air quality, multiple chemical sensitivity (Labarge and McCaffrey, 2000) and odour controls have limited conceptual shift in the way we understand and control risks.

Despite health being an important issue to people's lives, Harrison (2002) argued that people remain unaware and often apathetic of the health risks posed from indoor air. This could be argued as understandable when comparing priorities of high-risk activities and hazards. However, the effects of indoor air quality are indispensable in the economic impact in the workplace.

With the exception of schools and the associated Government guidelines (ODPM, 2006), often concerns are addressed within silo organisations and even on an individual basis, such as a complaint or a chemically sensitive person, which fails to provide a strategic approach for prevention. Strategies for managing indoor air quality in the workplace need to be formulised, not only to provide validity but to offer direction for those seeking guidance in addressing air quality concerns. Many of our standards today are based on the original findings from the 18th, 19th and 20th centuries, with the premise to remove odours and increase warmth for comfort basis by drying the atmosphere and limiting the air exchange. The pollutants experienced within the 18th and 19th century are very different to the pollutants affecting occupants of indoor environments today.

To summarise the literature review within the UK, there is limited resources evaluating the impact of IAQ, with the exception of schools (ODPM, 2006). This is further compounded by the lack of leadership, identity and a national strategy. The UK requires an organisation that is an equivalent to ASHRA or IAQA that specialises in providing UK resources, training, policy steerage and guidance for UK climates and conditions. Understanding the lack of research and implementation is complex, I therefore explore perceptions via my project activities and findings of surveying local authorities (push) and OHS practitioners (pull) as detailed within Chapter 4 and 5.

Whilst reviewing the status of indoor air quality within the UK, I found throughout my research a range of commercial services and products relating to improving the indoor environment, from monitoring services, air conditioners equipment, air ionisers to home testing air kits and alternative cleaning products. There are no regulating authorities for consultants offering to conduct indoor air quality surveying. There is a challenge to educate consumers regarding caution of purchasing commercial devices. To reduce poor air quality is really about education, product sourcing and at-source solutions. As there is no centralised commercial-free IAQ resources, information can be skewed by commercial gain and conflicting data due to the infinite material on the internet.

Even within my own project, I have been approached by many commercial product distributors and consultants who wish to sponsor my project or indeed request endorsement of their own products. I have faced challenges whereby commercial organisations have used literature I have written and have incorporated on their website designed to promote their products without my consent; of which they have been confronted to remove my details. Underpinning my project is the passion to raise the profile of IAQ in a non-profit forum that allows ease of access; as an action research epiphany, I therefore decided to integrate the development of an internet portal as an activity within my project as detailed within Chapter 4 and 5.

2.6.10 Positioning of IAQ and rationale for increasing awareness

My project is not only concerned with knowledge, but the ability to create effective change with the intention to develop a platform to continue contributing towards the agenda of IAQ. The intention is to develop understanding and motivation for IAQ and provide a continual accessible source of information. The evolving changes to our home and working environment, the products and building structures combine to present a real challenge to IAQ, a challenge that is dynamic, ever-changing and contingent upon the character of the economy, political willingness, understanding and society risk perception.

Currently within the UK, there are no specific indoor air quality courses offered by an accredited institution. Fourteen Universities within the UK offer modules on air quality via environmental pollution control and health, safety and hygiene qualifications. Glasgow Caledonian University's Centre for Research on Indoor Climate and Health, primarily focused attention on the factors that determine the indoor environment and the consequent effect on the health of the occupants. They previously offered an MSc in 'Indoor Air Climate and Health'. However since the writing of this paper, it has since been removed from their programme. Encouragingly, higher education facilities such as Reading University's Intelligent Buildings Laboratory (IBL) and Cranfield University's Institute of Environment and Health (IEH) are integrating IAQ within their research programmes.

Accredited courses by institutions such as IOSH (The Institution of Occupational Safety and Health) and NEBOSH (National Examination Board in Occupational Safety and Health) currently incorporate welfare arrangements including ventilation and thermal comfort, but fail to discuss indoor air quality as an influencing factor.

Due to the absence of specific indoor air quality courses within the UK, I have incorporated a review of global training programmes and syllabuses with the intention of pioneering the first IAQ accredited certificate in the UK.

A literature review of the Nato Science research papers (Boschi, 1999) of indoor air science educational programmes within Finland, Czech Republic, Hungary, Denmark, Italy, Poland, Romania, Bulgaria, Canada and the USA offer a varied interdisciplinary approach to the building process and the planning, design, construction, operation and maintenance of healthy, comfortable and energy efficient buildings. An encouraging read to understand the limitations and piecemeal application of the current IAQ education in Europe, but despite the exploration, it fails to discuss the real world application of IAQ and identify the transdisciplinary teams at which such education should be targeted.

There is a plethora of global organisations offering certification programmes addressing indoor environmental concerns. However, due to the lack of government regulation, many of these programmes are unaccredited and therefore I would question the integrity of the content. Several of the programmes are offered online with no evaluation of student's abilities and expertise. In 2006, the IAQ Council in the USA became the first organisation dedicated to indoor air quality to achieve an accreditation of their certification programme by the American Council for Accredited Certifications (ACAC). Therefore in considering a channel to develop knowledge and awareness I explore within this project the option of developing an IAQ training certificate that can be accredited by a national body in the UK and addresses UK's specific risk, policies and resources, which I discuss in section 4.2, page 162.

In considering teaching and training programmes in indoor air science and practice, a key point is that the area of study is interdisciplinary. Indoor air science includes the disciplines of construction physics, building material chemistry, contaminants of indoor sources, indoor/outdoor relationships, air conditioning and ventilation techniques, health effects such as sick building syndrome (SBS), building-related illnesses (BRI) and multi-chemical sensitivity (MCS) and also respiratory and cardiovascular diseases, risk assessment and risk management techniques with a multitude of stakeholders.

An awareness training programme had, however, to be tailored according to the target audience and the content of the IAQ council certificated programme was too extensive for the purpose of the training. The goal of my programme was to provide for a transdisciplinary team, such as facility managers and health and safety advisors, an appreciation of IAQ, the tools needed to help prevent and rectify indoor air quality problems in their building and build on existing skills/knowledge of risk and health management. Morawska, and Schwela, (2000) discuss knowledge transfer within the concept of indoor air science teaching programme and the emphases that:

> *'If there are no regulations (standards or guidelines), which would make it mandatory to address the issues of the quality of the indoor environment… the key aspects of training would be not to focus on what to do or how to do it, but on the need to do it'* (Morawska, and Schwela, 2000, p5).

This is a repetitive concern regarding introducing a marginal topic and therefore the programme should be weighted with rationale for IAQ awareness and linkage to financial and moral benefits.

The development of explicit knowledge and practical application to assess and control occupational risks from indoor air quality that accommodates the needs of business from both simplicity and cost does not require long investment in term of training. In other words, the approach to the evolving concerns of indoor air quality should not be considered requiring high expertise, but rather a core technical skill for multidisciplinary teams, such as OHS and EH Practitioners, facility managers, etc. Although it is acknowledged that each category of multidisciplinary teams will have different requirements, competencies and knowledge. There will also be different drivers for attendance from HVAC technicians (inspecting and servicing, responding to complaints, taking air and plate samples for analyses) to facilities managers (managing occupants' perception and comfort, managing service contractors). Therefore in contemplating the future of IAQ, specific training programmes are to be developed considering the training needs of the participant. As an example, an awareness course for OHS practitioners to raise the visibility of IAQ within the workplace, to a vocational qualification, such as City & Guilds for HVAC technicians to comply with their existing competencies. Due to the complexities of IAQ, embracing the intuitive practitioner approach, originally adopted within the medical field, may assist with traversing such complexities (Atkinson and Claxton, 2000); encouraging participants to cultivate their skills in developing knowledge from action can ensure sustainability of IAQ education.

Such controversial views regarding educating transdisciplinary teams are not intended to discredit the occupational hygiene profession, but merely to raise the agenda through established channels businesses currently invest, such as HVAC and facility management. Such views can be endorsed by the understanding of the traditional approach to hygienist monitoring and the decreasing visibility of occupational hygiene within the workplace. Statistics of the International Occupational Hygiene Association (IOHA) who represent the global community of occupational hygienists, show a decline in the number of members of occupational hygiene societies globally (Spee, 2006).

With the exception of Asia, with an increase which is considered due to the regulatory globalisation of processes exported (Spee, 2006); the global decrease is illustrated by a decrease of education and training programmes at a graduate level even in countries with a long-term tradition in this field. In Denmark, the Danish Occupational Hygiene Society was dismantled due to an insufficient number of members (Schneider, 2005). In the USA, the US News & World Report predicted in 1991 that occupational hygiene would become one of the 'top 20 professions' in this country (Burton, 2004). This prediction unfortunately has not been confirmed. Paradoxically, in parallel to this downward trend of occupational hygienists, several new issues have been emerging, which fit perfectly with the core competencies of such practitioners. The indispensable need for bridges between the different disciplines is achievable via a transdisciplinary approach. In this context, the transdisciplinary approach can be invaluable to also create the conditions for the emergence of new knowledge and the potential for creating ownership within organisations to manage the IAQ discipline. A transdisciplinary team could include non-traditional practitioners, such as human resource managers who currently deal with the problem of sick leave (absenteeism) but also have to cope with 'presenteeism' (presence at work without any motivation and with very bad productivity) (Aronson and Gustafsson, 2005). Financial managers who introduce economic performance indicators related to the quality of working conditions (strongly related to the quality of production) and to the workers' health (strongly related with motivation, commitment and productivity) (White et al., 2005) would be able to demonstrate a cost model for implementation. Clements-Croome (2006, 2008) provides compelling cost studies for such discussions.

> *'It is important to show clients the value of spending more capital on high-quality buildings that promote good ventilation' 'Hence ultimately produce healthier workplaces for people and give good value for money'* (Clements-Croome, 2008, p76).

If a curriculum is to reflect the inter-disciplinary topics of the subject, it is important that it addresses a range of broad topic areas with an emphasis on interdisciplinary perspectives (Chen & Hammer, 2006). Therefore a theoretical critique of existing IAQ syllabuses, websites and content enabled a gap analysis to identify underpinning competencies and secondly identify key expected learning outcomes and understanding of targeted students. To complement the awareness training, the motivation to learn will underpin my IAQ certificate.

The motivation for learning is critical and can be categorised within four stages (Locke, 2000), the need, the value, the goals or specific objectives and the emotion from the value of the experience. This theory is more accurately depicted within Keller 1979's model of motivation, performance and instructional influence, which centralises effort, performance and consequences as central to a person and environment inputs. Exploring pedagogies, I considered motivation and the output of transformative learning indispensable. Although transformative learning (Mezirow, 1991) is traditionally associated with self-learning and reflection, I have used this model to encourage such activity within the training certificate to encourage training participates to engage within IAQ literature.

> '*The key idea is to help the learners actively engage the concepts presented in the context of their own lives and collectively critically assess the justification of new knowledge'*.
> (Mezirow, 1997, p10.)

Therefore within the development of my IAQ certificate in chapter 4.2 page 162 I have included the facilitation of transformative learning, by discussing practical applications of IAQ and enquired participants own environments, thus allowing learners to use their own experience, understanding and perspectives to assist with engagement. Such application has value, particularly within a complex and dynamic topic.

> '*Education that fosters critically reflective thought, imaginative problem posing, and discourse is learner-centered, participatory, and interactive, and it involves group deliberation and group problem solving. Instructional materials reflect the real-life experiences of the learners and are designed to foster participation in small-group discussion to assess reasons, examine evidence, and arrive at a reflective judgment. Learning takes place through discovery and the imaginative use of metaphors to solve and redefine problems'* (Mezirow, 1997, p10).

Janik (2005) provides further clarification that learning is seen as:

> *'Volitional, curiosity-based, discovery-driven, and mentor-assisted*' (Janik, 2005, p144).

Furthermore Janik (2007) suggests that transformative learning (1) requires discomfort prior to discovery; (2) is rooted in students' experiences, needs, and interests; (3) is strengthened by emotive, sensory, and kinaesthetic experiences; (4) appreciates differences in learning between males and females, and (5) demands that educators acquire an understanding of a unique discourse and knowledge base of neurobiological systems. Although transformative learning is an educational model, I have considered my role within this transformative theory. The learning is more dynamic and as opposed to instructional, therefore my own ability to transverse the needs of the participants requires skills.

Taylor questions the role of an educator:

> '*Am I willing to transform in the process of helping my students transform? This means taking the position that without developing a deeper awareness of our own frames of reference and how they shape practice, there is little likelihood that we can foster change in others*' (Taylor, 2008, p13).

The ultimate goal of my certificate is not to provide an instructional programme that answers all questions, merely a professional learning environment, that is interactive, reflective, that incorporates real world application and provides a range of solutions, experience and knowledge; with the intention of nudging the professional community into their own transformative learning epiphanies. The activities of developing a certificate, accrediting the course with a national training centre and delivering the certificate is contained within the findings chapter.

2.7 Critical analysis of Literature Review

The aim of this chapter was to review and critique the literature relating to the area of IAQ. Upon critically evaluating the chosen research publications for this paper, I acknowledge the limitations of the rigid approach to understanding indoor air quality in context with other variables, such as combined contaminants, the political horizon, the changing landscape of contaminants such as perfumes, the cost effectiveness of modeling IAQ and the implementation of IAQ into real world environments.

Selecting papers of inclusion value within this project was challenging and several papers were rejected due to the silo topical approach, where the research had not considered variables into occupant's reported health conditions, production and comfort.

I also found the majority of research papers describing the impact of exposure occupants as a passive victim within the research; yet no discussions were drawn regarding their role to influence their own environment and levels of exposure. The most significant search findings were the geographically locations, the majority papers were sourced from the US, where failure to manage IAQ has resulted in different litigious and political responses.

There is a wealth of IAQ material accessed through subscripted journals, technical books and international conference, often academic in text, which potentially can limit transferability to for lay readers. IAQ topics are often hidden amongst discussions for climate change or building design, driving a selective audience and limited dissemination.

Government reports were often skewed claiming success of objectives, when often this was an insulated view.

A clear epiphany is the lack of identity for IAQ and furthermore a lack of willingness to create such identity from various stakeholders, which provides motivation to address such limitations within this project. Concepts do not exist in a vacuum and the silo effect of current research has limited transferability of findings. Due to the extensive written papers, an inclusion of key trends in IAQ research would be impossible to include within this paper, I have therefore selected papers that discuss the context of IAQ in society, policy, history and education.

The disparity and lack of ownership between the various UK agencies responsible for managing aspects of indoor air quality, the lack of interpretation and strategic direction following the WHO's action plan and guidelines and the lack of transferable explicit knowledge into industry has resulted in a low agenda of IAQ, despite the consistent evidence for the past 45 years regarding concerns. Within the literature review, there is substantial research demonstrating a correlation between indoor environments and health, yet minimum literature has been discussed regarding the strategy and management implementation of IAQ, with the exception of the schools programme. Therefore understanding the key stakeholder's perception and knowledge of IAQ and their potential influence is critical to understanding how to raise the awareness of IAQ in the UK. I reflected on the triple helix model and the challenges to traverse these three key stakeholders. ASHRAE have demonstrated a level of success in such integration; I found their openness to discuss their positioning in the IAQ arena and the gallant criticism of Government, professional bodies and the industry's lack of support refreshing and sincere.

To understand the theoretical connection with my own project, I reflected on my review and the concepts, gaps and integration of relationships that emerged from the data in order to yield a meaningful picture of IAQ within my project. A concluding thought is the conceptual framework that will influence my project activities to address the application of literature in terms of accessibility and transformative qualities.

2.8 The significance and shaping of my project; influencing factors from my literature review

To explore my research objectives, a wide diversity of interrelated themes has been considered within this literature review. At the beginning of my journey into my DProf programme I understood my passion for raising the visibility of IAQ, but lacked knowledge and direction regarding influencing change.

The literature review has enabled me to develop a strong theoretical understanding of IAQ, the application within a commercial setting, understanding local and political frameworks, the balance of leadership and transposition of theory, thus examining my academic ability and professional expertise in creating change within organisations via influencing behaviour and leadership. It has also shaped my project activities further with a fundamental aspiration to bridge the gap between academia and practical application. The literature themes have influenced the thinking behind the development of the design and methodology of the study and the requirement to apply a transformative activity that would address the balance.

The literature review has raised further questions around the UK positioning of IAQ, in particular the significance and indeed the risk perception against other health, safety and environmental agendas; how is IAQ managed in the UK by local authorities and OHS practitioners? Do occupants complain about their indoor environments? Are occupants as passive as we often illustrate within research papers? What is the risk perception of enforcement bodies? What is the understanding and risk perception of a transdisciplinary group? What value would be placed on providing resources and education? How should those resources influence as well as educate? I have explored these questions through my project activity surveys, as detailed in chapters 4 and 5.

The project is also designed to allow further discussion after my doctorate to continue the wider debate regarding IAQ, including challenging existing knowledge, reshaping awareness, influencing national policy, developing accessibility to IAQ topics and raising the agenda on a broader platform.

2.9 Conclusions

In comparison to other risks within health and safety, the exposure to a perceived low risk nuisance smell or an invisible contaminant can create a challenge in raising the awareness of IAQ impact to occupants and building management groups, particularly when those exposures of perfumes and scents can be pleasant for an individual. The growing focus of creating a sealed building and relying on mechanical ventilation to re-circulate a portion of the air we breathe that travels along dusty ducting and un-serviced filters exasperates the problem. Odour perception as a primal sense is being masked by harmful artificial aromas, therefore skewing our ability to detect harm, making us more susceptible to exposure.

Malfroy (2004) discusses Lee et al., (2000) concept of the hybrid curriculum which centres on the three intersecting spheres of university, profession and workplace, which draws a parallel to the triple helix model discussed. Malfroy (2004) elucidates:

> '*The real preoccupation of researchers is not the theory of workplace practice but the theory of their discipline and how it is mediated in work contexts'* (Malfroy, 2004, p71),

Malfory (2004) recognised that change management is an essential dominated factor of practitioners and suggests a hybrid curriculum should advocate university, professional practice and change management. Malfory's view shaped the fundamental rationale of this project to ensure transferability of an IAQ agenda within a real world environment.

The vigour of IAQ is reliant on an academic arena and therefore to ensure sustainability of a health agenda, a diversity of stakeholders are required to create a pull from society and a push from research. Therefore within my own project activities I explore the perception/significance of IAQ.

The history of IAQ provides a rationale to the development of the science and a comprehension of how our air quality standards have been developed. Such understanding exposes a weakness in applied standards of IAQ in a changing modern society. To exasperate this further, the lack of resources, policy-makers interest, limited knowledge, lack of future planning and debate will escalate the frailty of IAQ awareness and agenda. History can suggest lessons and parallels and provide wisdom as we look to the future. However, as we continue to build an artificial environment, we need to balance our debate regarding the impact on the occupants.

The literature review has provided a setting for my project activities and steerage regarding the surveying of EHPs and OHS practitioners to gauge their risk perception and knowledge of IAQ as discussed in chapters 4 and 5. The triangulation of literature review findings and the surveys will ultimately shape the development of training and website resources for a range of lay and expert parties.

<u>Chapter 3 – Methodology & Design</u>

3.1 Methodology Introduction

Chapter 3 provides an overview of the methodologies explored and chosen for my work based learning project. The chapter defines three critical areas of my methodology – surveys, action research and methodology considerations, incorporating transferability of literature, change management and ethical considerations. Trauth (2001) describes how the researcher's theoretical lens plays an important role when choosing a methodology because the ontological assumptions (underlying belief system) define the choice of method. Hitchcock and Hughes (1995) suggest that:

> '*Ontological assumptions give rise to epistemological assumptions which give rise to methodological considerations, which in turn give rise to issues regarding instrumentation and data collection'* (Hitchcock and Hughes, 1995, p21).

Within my reflective accounts, I found difficulties in structuring a rigid methodological composition. My inquisitive ethnographical approach would have preferred a qualitative data collection that allowed me to become:

> '*Immersed in it and to move into the culture or organisation being studied and experience what it is like to be a part of it. Rather than approaching measurement with the idea of constructing a fixed instrument or set of questions'* (Krauss, 2005, p760).

Krauss (2005) defines the qualitative researcher who allows questions to emerge and change. However due to the broad topic of IAQ and the understanding that was drawn from my literature review I have chosen a quantitative structure for the surveys, using specific questions that required data collection and analysis. Quantitative studies involve much inductive reasoning, whereas good qualitative analysis can create a platform of data for further exploration and discussion which will be underpinned by my work based activities, interdisciplinary knowledge and skills. McKenzie (1999) criticises pure statistical data, stating readers may not consider the social application of the research, suggesting that qualitative factors assist in establishing a conclusion. Therefore quantitative data from the surveys will be triangulated with qualitative feedback from my IAQUK internet site and training certificate, as discussed in chapter 4, using a mixed methodology approach. Although such methodologies have their critics:

> '*Our own thinking to date suggests that the notion of mixing paradigms is problematic for designs with triangulation or complementary purposes, acceptable but still problematic for designs with a development or expansion intent, and actively encouraged for designs with an initiation intent'* (Greene et al., 1989, p271).

> *'The question, then, is not whether the two sorts of data and associated methods can be linked during study design, but whether it should be done, how it will be done, and for what purposes*' (Miles and Huberman,1994, p41).

Tashakkori et al., (2003) provide clarity in the mixed methodology model by identifying three paradigms, quantitative and qualitative data, with the third aspect being a worldview of its own. Tashakkori et al., (2003) is essentially describing the triangulation of data with consideration of a real work environment. Hunter and Brewer (2003) also support the multi-method approach as:

'A strategy for overcoming each method's weaknesses and limitations by deliberately combining different types of methods within the same investigations' (Hunter and Brewer, 2003, p578).

Creswell (2007) declared that to gain validity of research, particularly within a social application, illustrating the research approach is an effective methodology. Therefore this chapter is dedicated to providing a framework for the methodology used and the rationale for selected approach which is illustrated in a schematic, figure 6, page 125. I have chosen an illustration to provide a clear view of a dynamic project that has evolved within the boundaries of an action research approach, with the intention of effective transformational activities.

'What distinguishes action research from other forms of enquiry are its transformative intentions' (Eliott, 1997, p25).

The methodology is underpinned by the aim to apply theory into a practical application; therefore the structure consists of reviewing existing guidance and competency standards and conducting a gap analysis to integrate indoor air quality into a transferable format for sequential training, competence standards and an internet resource portal.

'*The basic concept is that knowledge claims must be set within the conditions of the world today'* (Creswell, 2007 p25).

The methodology will offer structure and a strategy throughout the research project shaping the direction and boundaries, with an underlining reflection process to ensure the transferability of the findings into practical application.

I have therefore reflected on Crotty's (1998, p4) four elements.

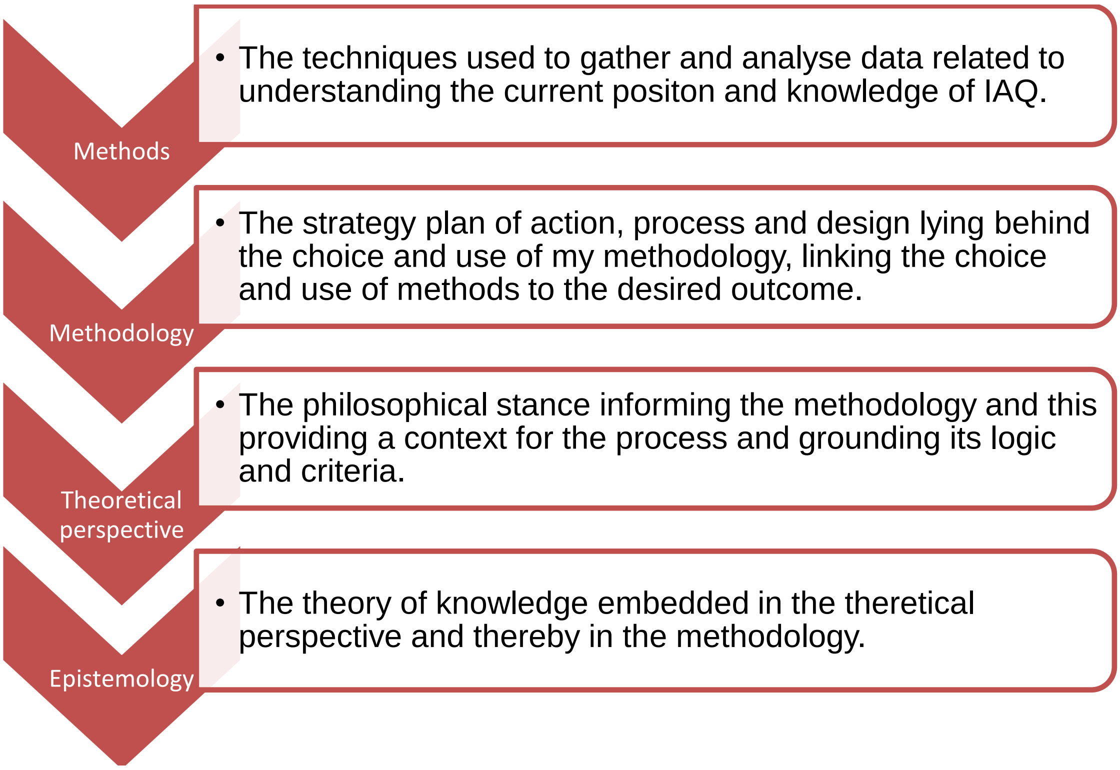

Figure 5: My illustration of Crotty's (1998, p4) four elements structure.
Four distinct reflective pillars that create a layering effect to methodological approach.

Crotty (1998) distinctly informs the reader about the four elements and that :

> *'Lumping them together without distinction is a bit like talking about putting tomato sauce, condiments and groceries in one basket. One feels compelled to say "hang on a moment! Tomato sauce is one of many forms of condiments. And all condiments are groceries. Let's do some sorting out here'* (Crotty, 1998, p3).

Crotty is clear that the 'grab-bag' style is not uncommon and that researchers should consciously consider the different layers of methodology and how they consistently fit together, thus providing rigour to the research.

Indeed my project will evolve by gathering data from quantitative and qualitative sources, using reflection, triangulation and action research which will create a layering effect of data to shape my project activities. Using mixed methods within the project will provide a wider breadth to the research, stimulating new debate. Morse (2003) described mixed method programmes as:

> *'When a series of projects are interrelated within a broad topic and designed to solve an overall research problem'* (Morse 2003, p196).

Mixed method designs does have critics, Freshwater (2007) argues mixed methodology overstates its ability to reveal the truth, accusing idolisation particularly within nursing and healthcare literature (Freshwater, 2010, p141). She further states that such methodology was moving away from indeterminacy and moving towards incontestability (p137) resulting in third person writing that was flat and displayed a sense of incompleteness (p138).

Tashakkori and Teddlie (2003) recommend writers should insert questions within their research to acknowledge messiness or blurred borders of mixed method research. Within this thesis I have recognized that the driver of my project is to create knowledge and understanding, to ultimately bring about change in the visibility of IAQ in the UK, as discussed on page 16. Such conversations are unquantifiable with regards to outcome, and potentially can diminish the coherence and clarity in my findings; therefore I have included such complexities within the dialogue of my project.

Plowright (2011, p4) offers a different perspective of mixed methods, rejecting the traditional view that philosophy determines methods, suggesting the alternative of the reverse. This concept assists with understanding and conceptualising the research process without becoming constrained by existing research frameworks.

Within my research, the laying effect of action research allows a sense of freedom to explore my subject. Denzin (2010) validates the use of mixed methods designs:

> *'No one could refute the argument that the use of more than one method produced stronger inferences, answered research questions that other methodologies could not, and allowed for greater diversity of findings'* (Denzin, 2010, p422).

Despite the breadth of discovery, Freshwater (2007) caution resonates and thus clear objectives with helicopter visual illustrations of my methodology is an important factor to ensure the borders do not become too blurred.

As discussed within my literature review, IAQ is often represented in silo topical debate, hidden in alternative subject matter such as climate change and building design, skewed by government reports with disparate resources, an absence of ownership and direction; reinforced by the paucity of application to a real world environment and sparse evaluation of a changing society. Mingers (2001) discusses such complexities of research in a multi-dimensional world, encountering problems and addressing interventions. Mingers (2001) elucidates:

> 'A*dopting a particular paradigm is like viewing the world through a particular instrument such as a telescope, an X-ray machine, or an electron microscope. Each reveals certain aspects, but each is blind to others*' (Mingers, 2001 p5).

Mingers (2001) expressed that one method of research is restricting to providing only one view and that research activity of multi methods should develop a relationship with three worlds - the material world (observations), the social world (participation), and the personal world (experience).

Minger's model of gathering data across silo disciplines represents a cornerstone to the ethos of this paper in understanding real world application, using my existing skill, knowledge and experience and engaging with key stakeholders to understand their three world relationships. Tashakkori and Teddlie (1998) indicate three further benefits to multi-method mixed research:

- Triangulation - seeking to validate data;
- Creativity - discovering fresh or paradoxical factors;
- Expansion - widening the scope of the study.

Creating such structure within my methodology provided freedom to traverse the literature review silos and influence my project activities. Consequently using a broad paradigm of multi-dimensional methodology resulted in a layering effect - horizontally offering broadness and scope, vertically a depth and richness to my discussions; complimented with triangulation of my literature review, surveys, feedback from my training and the IAQUK websites responses and my own reflections as an OHS practitioner to stimulate new discussions. Denzin (1978) identified four types of triangulation: Data triangulation: investigator triangulation: theory triangulation and methodological triangulation. For the purpose of this project, I have chosen data triangulation as a real world application. According to Begley (1996, p122) data triangulation's robustness can be based on the time the data was collected, people involved in the data collection and the setting which the data was collected. Within my project the enforcement authorities (push) and OHS practitioners (pull), as discussed on page 29, are different environments with different drivers, however the surveys are gathering a similar perspective on understanding, knowledge and risk perception of IAQ.

Combining quantitative and qualitative methods provides data that is unbiased and enables cross examination of findings. Both qualitative and quantitative studies are designed:

> *'To understand and explain behaviour and events, their components, antecedents, corollaries, and consequences'* (Dzurec and Abraham, 1993, p76).

It also provides validity to the study (Boyd, 2000) and

> *'Involves the use of multiple source to enhance the rigour of research'* (Robson, 2002, p174).

Furthermore it is essential that the project is written for the intended user, therefore creating a comprehensive multi-perspective view (Boyd, 2000). Methodological triangulation also has weaknesses, as discussed by Polit and Hungler (1995), including the lack of expertise to correlate numerical and narrative data leading to conflict of research design that may weaken the validity of the project, consequently leading to reluctances of editors to publish multi-method works. By providing raw data within the appendix, readers can determine their own views and test the hypothesis presented in my project, evaluating my findings and providing a platform for further discussions and research. Triangulation for the validity of evaluation and research findings will be critical within the research strategy (Denzin, 1989). Cross validation will draw additional dimensions to the findings; however a conceptual framework will be implemented to develop a wider discussion that embraces multi-methodology perspectives that is underpinned by quantitative and qualitative data within a practical environment, thus providing value of content. The silo research methodology that exists with indoor air quality will be concept mapped to:

> *'Assimilate new concepts and propositions into existing cognitive structures'* (Novak, 1993, p172).

Mingers (2001, p245) identifies four phases of appreciation, analysis, assessment and action, which I have applied within my methodology:

- **Appreciation** of the research positioning, as experienced by the researcher and actors (local authorities and OHS practitioners) involved; which incorporates the literature, observations, surveys and qualitative feedback. The project will require consultation with governing bodies and existing practitioners in order to generate a collaborative approach to managing indoor air quality within the UK.
- **Analysis of the data** to understand the history that has generated it, and the structure and boundaries of the application. Analysis methods appropriate to the methodology of my study will be presented by raw data and simple statistical presentations in the format of data grouping and analysis of linear relationship of variables; thus ensuring transferability for the non-academic reader.
- **Assessment** and discussion of the findings within an action research model that incorporates triangulation and reflection. The assessment phase is underpinned by ethical, social, economic and political influences.
- **Action to report** on and disseminate the research findings with the intention to bring about change to the IAQ agenda. I consider this project as a journey and not as an end point; therefore as phases of the project developed, I included within the methodology design considerations for transferability of literature, change management, strategy for dissemination and the evaluation of deliverable objectives.

Mingers (2001, p246) emphasizes that these activities are not seen as discrete stages that are enacted one by one, influencing the project progression. I have illustrated a schematic outline for the project within figure 6, as shown below which provides a helicopter view of the project and how action research has been adopted.

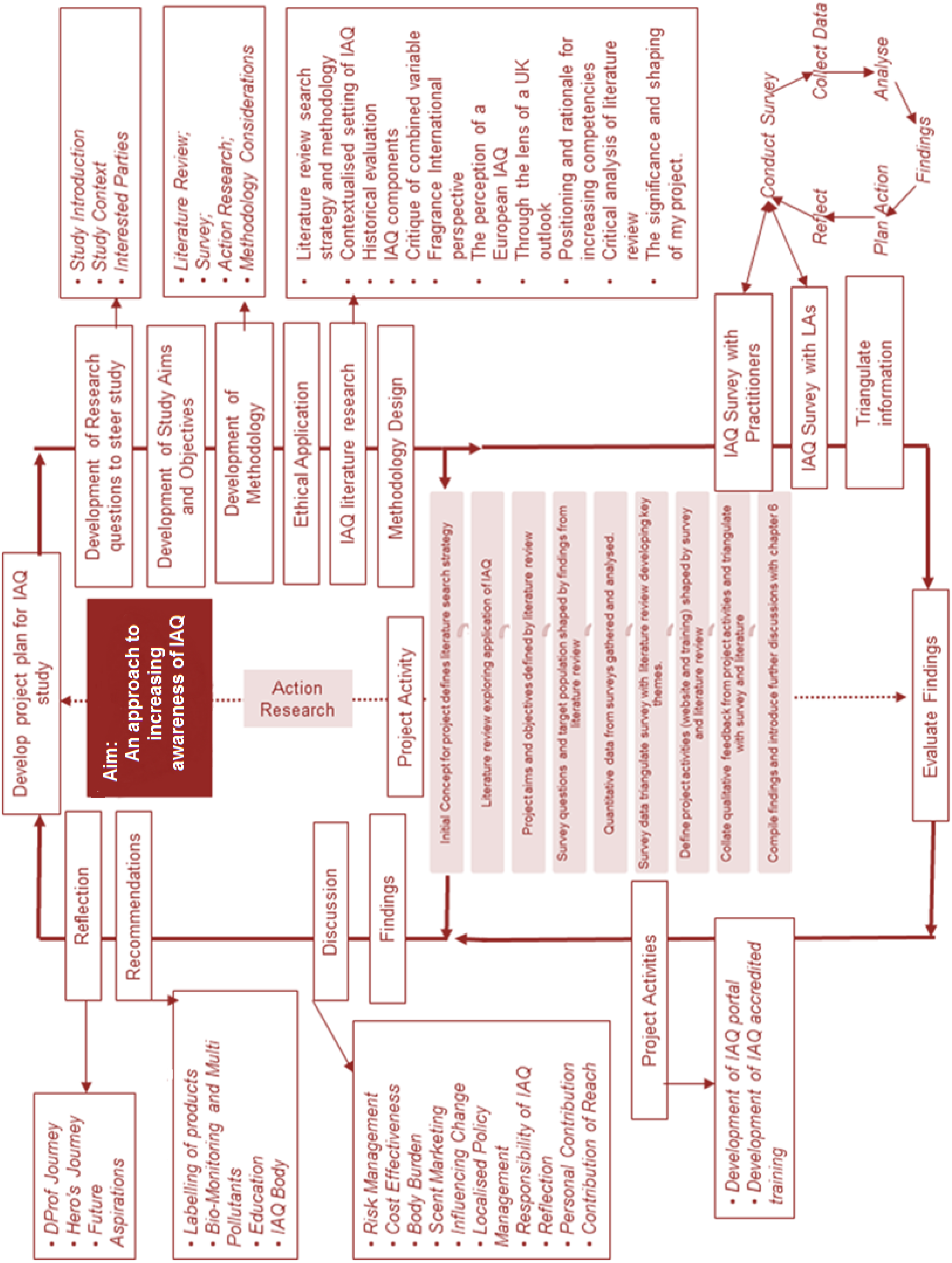

Figure 6: Schematic outline of Project

A helicopter view of my project.

3.2 Surveys

To explore risk perception and understanding within a real world situation, two types of surveys, targeting different populations were sampled. I have selected two key stakeholders groups, who I consider fundamental to the interpretation and practical implementation of IAQ - enforcement authorities (push) and OHS practitioners (pull). The choice for the two survey modes were influenced by four key factors, cost, timescale, coverage of targeted population and flexibility of asking questions. The surveys as illustrated in figure 7 below were implemented via:

- Local authorities survey;
  Questionnaire to be emailed directly to selected population.
- OHS practitioner's online survey;
  Online survey located on the www.iaquk.org.uk website.

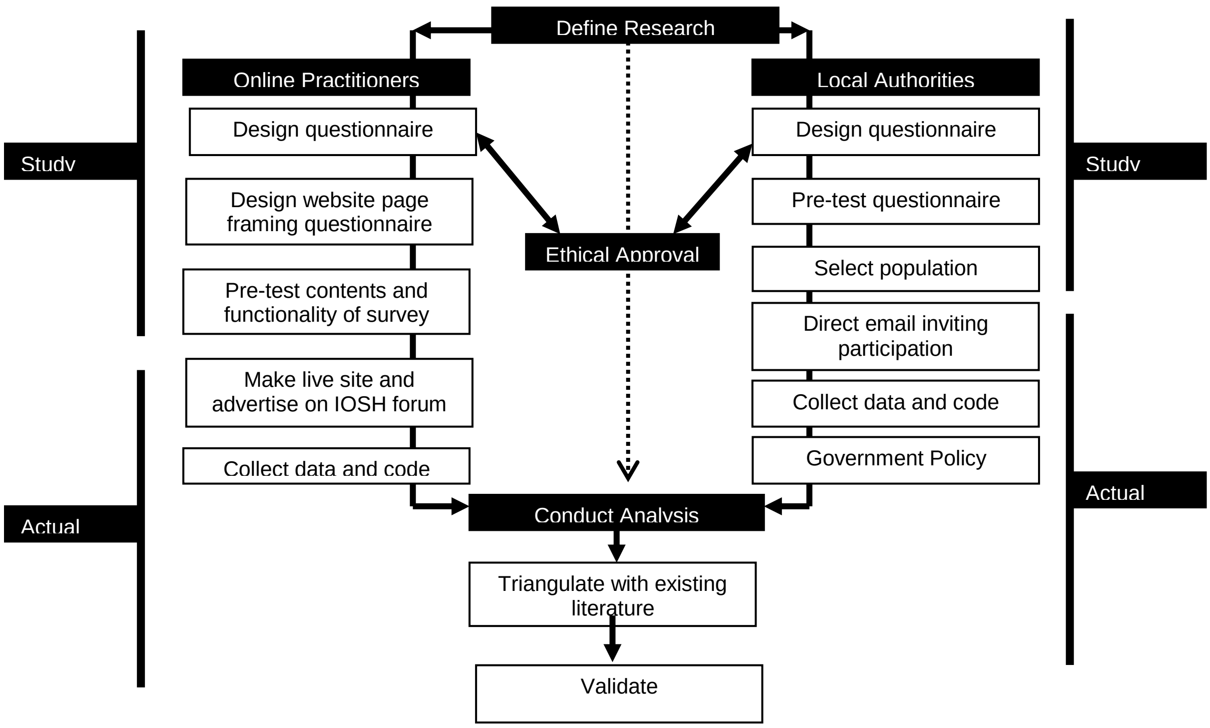

Figure 7: Schematic of surveys

An illustration detailing the stages of methoodology for the OHS practitioners' online survey and the local authorities' emailed questionnaire.

Surveys are not always the most accurate form of gathering data and are reliant on the participant's subjective view. Survey questions can create bias participant judgments and answers (Schwarz, 1999). Traditionally research requires valid, reliable measurement of data to confirm validity, therefore within my two surveys I have built weighted responses to questions to enable statistical analysis; however the perception and subjective view of responses are just as legitimate as evidential data and have an inclusion value within my project.

Local Authorities Survey

Reviewing questionnaires within IAQ literature, the participants are predominantly the occupants, with limited focus on the ownership or enforcement of IAQ. I therefore provide a new perspective. Thus, the purpose of the survey was to identify potential gaps from the theory of indoor air quality to practical application. I included an exploration of knowledge and attitudes of comparable risks; their interaction with IAQ within their existing activities and I provided an opportunity to discuss resources of IAQ. Normative data is provided within this report to support future analysis within the industry.

Design of Questionnaire for local authorities

The questionnaire was seen as the primary method of gathering information within this study and as a result the design of the questionnaire was crucial to ensure relevant data is sourced from respondents. To avoid ambiguity and confusion, careful consideration was contemplated with the type and design of questions (Youngman, 1982). Sherblom et al., (1993) proposed five questions to answer to assure significant and useful study results:

- What do we want to know?
- About whom do we want to know it?
- How do we word the questions?
- How do we elicit appropriate and adequate responses?
- How do we interpret the results?

These questions provide very simple starting points and seminal concepts, I therefore compiled a series of questions for the survey that were stimulated from my literature review and categorised responses. The questionnaire was divided into four sections:

- Significance of IAQ;
- Management of IAQ;
- Education and Resources;
- Further comments.

The survey used closed-end questions in order to collect quantitative data. Multiple-choice questions were provided for the respondents using a Likert scale (Likert, 1932), asking participants to evaluate the importance of pre-set statements from none, low, indifferent, reasonable and significant. An agreement scale was also used for direct responses to objective questions.

Each section provided an opportunity for the participant to comment further. Designing a scale with an equal number of positive and negative statements can create central tendency whereby a view is presented neutrally, however this bias may also provide useful information as to the perception of IAQ.

Within the questionnaire there was a final open question to allow the respondent to propose any further variables within the survey. Such open questions can pose difficulties in analysing data. Open responses received during the main survey were evaluated for exploration, without causing distortion of data. Remaining responses are summarised within the chapter on findings, page 196. Double, leading, presumption and hypothetical questions have been avoided, to prevent distortion of data. The questionnaire was computer-processed with consideration for appearance and layout. A copy of the questionnaire is published within appendix 4, page 397.

Pre-test (pilot) questionnaire for local authorities

The validity of questions and reliability of methodology was examined prior to conducting the survey. Pre-test questionnaires were sent via email to nine OHS practitioners and one Local Authority which included the participant's information sheet. Upon receipt of completed questionnaires, I followed up with a phone call to discuss the pre-test. Shelby et al., (1982) recommended pre-test should include questions about the questionnaire itself, items about specific questions and items regarding data analysis. Pre-testing ensures:

> '*That the questions asked are clear and the response options are comprehensive and appropriate'* (Queeney, 1995, p146).

McCampbell and Stewart (1992, p58) addressed the benefits of pre-tests by stating how pre-tests can reduce time in editing the first round questionnaire, reduces dropout rates as the researcher can refine their questions for inclusion and ensures any omitted data by the researcher is included. Therefore I reflected on Salant and Dillman (1994) to consider suitable pre-test questions:

- Does each question measure what it is supposed to measure?
- Do respondents understand all the words?
- Do all respondents interpret the question in the same way?
- Are all response choices appropriate?
- Do respondents correctly follow directions?
- Does it create a positive impression that motivates people to respond?
- Do the questions flow within the four categories?
- Is there sufficient space to provide further commentary?
- How long does it take to complete?
- Does it collect the information I want?

Comments and suggestions on question item sequence and wording choices were also solicited; this led to few minor modifications to the questionnaire.

Findings from Pre-Test for local authorities

The key conversations focused on the changes within industry due to Lord Young's Common Sense, Common Safety report (DWP, 2010) and budget cuts which presented an extra dimension to understanding IAQ in correlation with other risks. Therefore I included an extra question to incorporate this dimension within the distributed survey. The key reflective point from the pre-tests, aside from the structure of the questions, was the political influence of IAQ and the competing demands placed upon local authorities. It became clear that to drive IAQ, the policy makers would influence the visibility and agenda setting. When I started the DProf journey, my initial intentions were to explore the general knowledge of OHS practitioners and local authorities, however listening to the responses from participants; I have dedicated much of this chapter to discussions focusing on a strategic direction for IAQ with further recommendations to inspire further debate.

I decided not to use the local authorities pre-test findings within the main findings that are discussed in chapter 5; this decision is based on two factors. Firstly the pre-test sample group included only one EHO, the remaining were OHS practitioners and therefore did not represent the targeted group. Secondly the individuals selected for the pre-test were existing associates who were already engaged in the IAQ debate and were aware of my project aims, which would skew the opinions provided. Their results provided a similar response to main findings and no significant data was provided that warranted a separate analysis.

Ethical Approval for local authorities Survey

Human research is the basis for this report discussing health effects, perception and performance; therefore ethical approval had been granted from Middlesex University prior to any research conducted, as included in appendix 19, page 491.

Guidance information was provided for all participants explaining the aims and objectives of the research and included details of how to request further information. The completion of the questionnaires was accepted as individuals consent to participating. All participants had been assured of anonymity and confidentiality via the guidance information.

Sampling for local authorities Survey

240 environmental health departments within local authorities within the UK were selected for the study population. The local authorities were identified using the Direct Gov. website (Direct Gov, 2010) and each Council's internet site was accessed to gain contact detail. Each environmental health office was invited by email directed to a named representative to participate within a survey on indoor air quality in November 2010. Accompanied with the email contained a participation information sheet providing the ethical guidelines of the survey, as detailed within appendix 3, page 395.

Cook et al., (2000) conducted meta-analysis of 68 web surveys and summarised that personalised contacts with respondents, such as a direct email has a positive impact on response rates. Sproull (1986) proposed four characteristics of using electronic medium as communication for research methods:

- Speed (faster response rates);
- Asynchronous communication (interactions can be at the convenience of the user);
- No intermediaries (increase opportunity of interaction as the respondent is directly engaged with the survey);
- Ethereality (respondent responds in a more candid fashion).

All questionnaires were encoded to allow double checking of data inputted into statistical software. All data, whether written or computerised, is kept secure in accordance with the Data Protection Act 1998 (HMSO, 1998), thus maintaining anonymity of individuals and the organisation.

An encoding system used for individuals who participate within the research will also be kept confidential to prevent any security tracing issues. All documents will be kept for three years, upon completion of the DProf programme, and then destroyed. A full report was offered to the organisations and participants on request, although no authorities requested such information. local authorities were also offered access to guidance on how to measure and monitor indoor air quality, providing recommendations on a management implementation programme, as an outcome of the research. All participants received identical information in November 2010 with a requested 3 month response period. Non respondents received one reminder email after 8 weeks. Findings are discussed within chapter 5.

OHS practitioner's Online Survey

I consider OHS practitioners as the key body of individuals who would implement IAQ within workplaces, due to existing risk management skills, knowledge of substance evaluation and monitoring, and the advantage of often assuming an interactive role within business. An online survey was chosen as a source of interaction as this is a growing method of surveying (Couper, 2000), although this is not as successful with regards to response rates when compared to mailed surveys, which Sills and Song (2002) attributes to concerns of recipients relating to security of information and junk mail.

<u>Design of OHS practitioner's survey</u>

The survey was presented in full format on the IAQUK website (www.iaquk.org.uk) which I owned, developed and designed, as part of the project activities. I decided to provide a simple format so that the respondent could see all the questions on one page and respond accordingly. The intentions of the questions were to evaluate existing knowledge, such as time spent indoors, types of health complaints in comparison with building type, age and activities within.

The second part of the questionnaire appraised management of IAQ, exploring monitoring methods and resources and providing an opportunity for respondents to rate the importance of IAQ. The series of questions were presented using clicked radio buttons to provide quantitative data, with text boxes for additional responses. I considered the location of the survey to be presented on the IAQUK website, rather than a separate questionnaire hosting site, with the intention to encourage respondents to navigate further around the site.

Pre-test of OHS practitioner's survey

Prior to advertising the survey on IOSH forum, I invited 9 OHS practitioners to compete the survey to test the validity. I phoned the respondents upon completion to discuss the sequence and wording choices. Few minor modifications were made. The key focus centred on the software technology in capturing and transferring the data, with some data absence from the notification emails, such errors were resolved during the pre-testing stages. Subjects who had participated in the pre-tests were excluded from the subsequent study. This decision is based on two factors. Firstly the pre-test sample group included an EHO, the remaining were OHS practitioners and therefore did not represent the targeted group. Secondly the individuals selected for the pre-test were existing associates who were already engaged in the IAQ debate and were aware of my project aims, which would skew the opinions provided.

Ethical Approval of OHS practitioner's survey

The human research is the basis for this thesis discussing health effects, perception and performance; therefore the survey had been included within the ethical approval application which had been granted from Middlesex University prior to any research conducted. Respondents were informed that the responses would be posted on the IAQUK website, assuring anonymity. As the website host I would receive a notification email with the respondent's answers. I was then able to transfer the information into an Excel database for further analysis.

The advantage of using my own site to host the survey ensured no interference from secondary parties handling the data. Upon completion of a questionnaire, the respondents received a thank you email for their participation and a contact name and number should they require any further information regarding the survey or IAQ

Sampling for OHS practitioner's survey

IOSH is Europe's leading body for health and safety professionals, with nearly 33,000 members worldwide (IOSH, 2008). Therefore the IOSH forum was seen as the most effective manner of connecting with a wide audience within the health and safety field. A population that regularly uses the internet with high hits on messages within the IOSH forum framework. An invitation was posted on the training section of the forum asking for voluntary participation. Couper (2000) cited benefits of time, cost savings and having returned survey data already in an electronic format when using internet surveys.

Analysis of data of both surveys

An analysis of the exploratory data was conducted looking at raw data to decide on their important features. Weighted ratings were applied to the answers to enable a standard means calculation. Where applicable, data was grouped to analyse a linear relationships. Variables were selected to demonstrate relationship of similarities and differences, identifying any correlation of interest such as risk perception, knowledge and management of IAQ. Full details regarding the analysis of data is included within the findings chapter, page 196.

Translating qualitative data and the diverse, complex and nuanced approaches (Holloway and Todres, 2003), a thematic analysis was used which encouraged an active role in identifying themes and emerging concepts.

Braun and Clarke (2006) propose six phases for a thematic approach, as detailed below in table 5 which I have considered as part of my research methodology.

Table 5: Stages of thematic analysis.

Consideration of Braun and Clarke (2006) six phases for a thematic approach within my project methodology.

Phase	Description of my project thematic approach
1. Familiarising yourself with the data	• Answers from the surveys were weighted and entered into an excel spreadsheet. • Any comments were transcribed onto a separate spreadsheet for analysis. • Any emerging, common themes were grouped.
2. Generating initial codes	• All answers were weighted and coded. • Data was collated in a systematic manner.
3. Searching for themes	• Data was grouped into emerging themes. • Clear titles/headers were provided for each theme. • No data was discarded as irrelevant.
4. Reviewing themes	• Grouped data was plotted on a mind map to identify themes.
5. Defining and naming themes	• Further analysis was conducted to refine the specifics of each theme. • Information was triangulated with literature review.
6. Producing the report	• Sections of compelling extracts and summary conclusions were incorporated into the findings section of my project for further discussion.

Braun and Clarke (2006) summarise that although thematic analysis has no 'kudos' within the analytical arena, a rigorous approach can produce insightful findings that encourages flexibility across a range of epistemology and research questions. A visual thematic concept table was incorporated within my findings chapter, page 196 of this project.

Open and available data is essential to demonstrate transparency, to enable individuals to challenge your hypothesis and encourage contributing research to current findings. Therefore histograms are published within the appendix for each question accompanied with the raw data to support future studies and discussions, a standard mean table is presented with each discussion in the findings chapter, along with line, radar and bar charts.

Findings from both surveys are presented in chapter 5.

3.3 Action research

Through my journey of understanding IAQ, I have traversed many silo topics and have been open to reflection and learning throughout. Such organic application can skew the direction of my DProf project and therefore I have chosen to include Action Research as part of my methodology to enable a coherent collection of thoughts that have an inclusive factor within my programme.

The underlying principle of my project is the application in the real world environment, supported by both theory and practice, often seen as a dichotomy, as opposed to an integrated, complimentary praxis. Within my own experience, I consider action research and the praxis of active learning as exploratory, reflective, evaluating, considerate of depth and breadth, inquisitive and advance of knowledge. According to this paradigm both knowledge and practice are equally needed. Knowledge is derived from practice, and practice informed by knowledge.

There are several permutations of explanation for action research that have evolved since Lewis (1946) proposed that research needed to produce more than just books. Action research is driven by the value contributed towards field and therefore can be complex due to uncertainty, conflict, multiple perspectives and multiple stakeholders (SLIM, 2004), but instrumental due to the approach the knowledge gained is knowledge applied. Sommer and Sommer (2002) categorize a successful application of action research where the:

> '*Participates are better off after the research than before* it' (Sommer and Sommer, 2002, p211).

McNiff (2002, p10) describes action research as a form of personal self-evaluation, which creates contexts for critical conversations in which all participants can learn as equals. This clarifies that the desire for new knowledge and the need to solve a problem should have complimentary measures of application from both the researcher and participants. McNiff depicts a balanced relationship, a partnership, between practitioner and supporter whereby both can challenge and supportively critic. McNiff is suggesting that the researcher may not have all the answers, via lack of confidence or skill. Therefore, as a researcher, I must acknowledge and accept accountability for such deficiencies.

I found Schon's (1983) analogy of high ground research (hard, rigorous, controlled, standardised methods) and swamp (problematic, lack of technical rigor) an interesting account. Both have value and I abstain from criticism of traditional research that lacks real world research application, as I navigate my swamp:

> *'Sticky and full of unknown creatures'* (Farbstein and Kantrowitx, 1990, p297).

Aside from the contributing factors of combined knowledge and experience, action research provides value to me as a researcher (developing new understanding from alternative sources) and value from me as a researcher (experience and competencies applied to the project). Consequently throughout this project I discuss my reflections and active learning as I immerse within the IAQ arena, such cyclical actions provide a vehicle for a meaningful experience throughout my DProf programme, providing self-directed inquisitive understanding and discovery.

As illustrated by figure 8 below, within my own action research model, I have decided to use plan, act, observe, and reflect. To incorporate the inherent complexity of the project, action research as a methodological approach was significantly used; thus acknowledging the diverse stakeholders, the reflecting learning from the literature review and data collection and analysis from the surveys, training evaluations and website statistics; consequently providing a positivistic approach to the collation of data with the intention of a naturalistic approach to understanding situations and people.

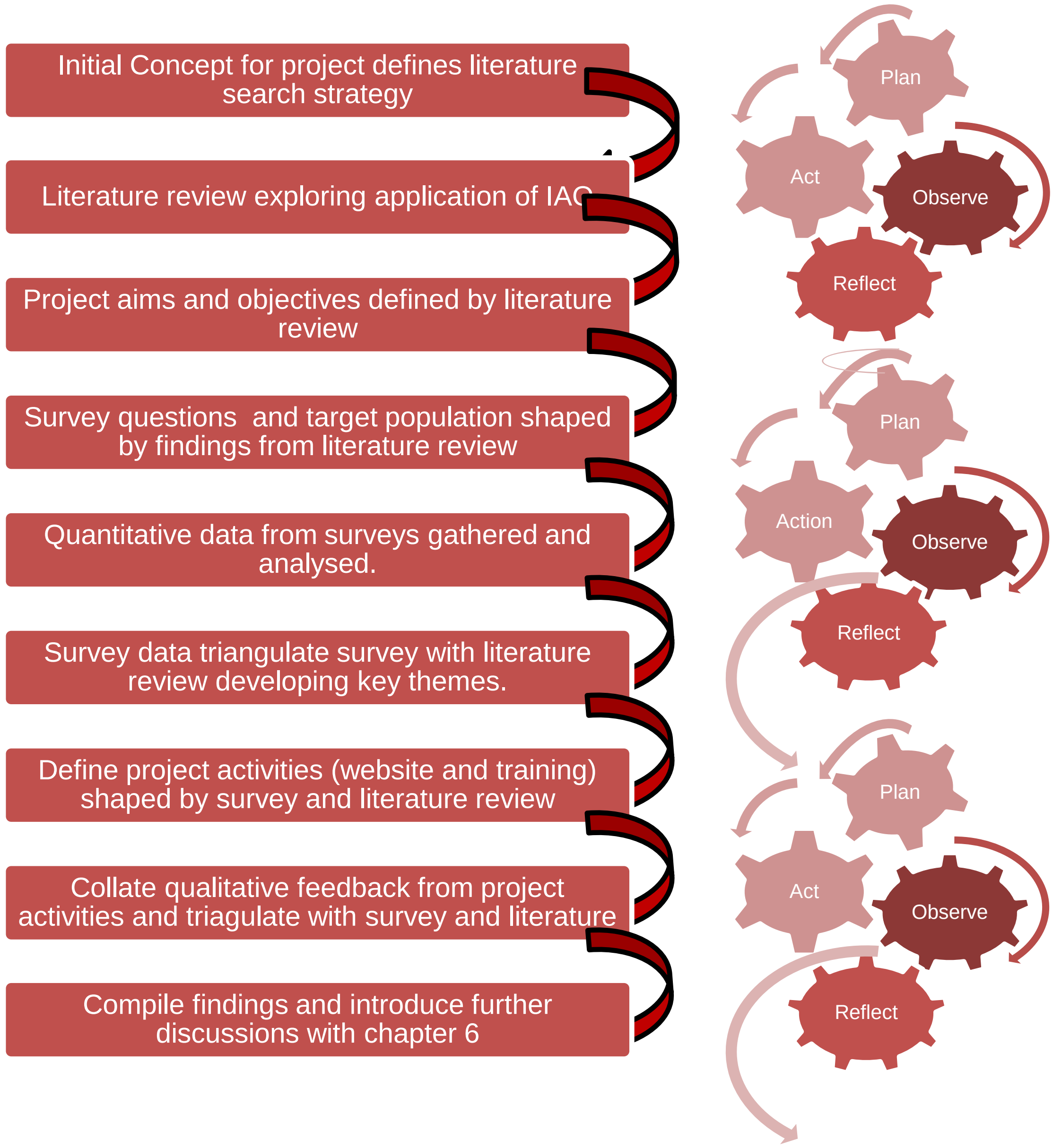

Figure 8: Illustration of project action research events.

Project action research model indicating plan, action and influence events used to shape methodology.

I do not see the action research cycles as separate, but as an influencing, layering process that also shapes my reflection as an active learner within a work based project. I have defined the layering action research events within chapter 5 of my findings page 196 discussing how each stage influenced the next.

A further consideration for inclusion value of action research is recognising the broad scope of IAQ discussions and the limitation to include all dialogue, therefore by providing an open account of actions and reflective points, further research can be cultivated.

The purpose of such transparency is to allow different understandings of theory to emerge from action research that the reader may agree, criticise, analyse or develop further. The findings and discussions included within this project are shaped by my own experiences and that are stakeholders who have contributed towards this project. Lumley describes such dynamic relationships that:

> *'Allows us to understand the dynamics of the common living-space in which we are all ineluctably included participants'* (Lumley, 2008, p3.)

Therefore within my project I have included activities that engage with key stakeholders within the format of surveys. However, there is an unconscious participation weaved throughout this project, the engagement and conversations with people who I have discussed my DProf programme, their inquisitive interest or questioning has also provided learning points. Therefore by maintaining a diary and referring to key epiphanies throughout this paper, I intend to also provide an ethnography account.

Within my researcher role I applied an active reflective activity at each stage of the action research model with the intention of providing depth and context to my journey (Hubbard and Power, 1993). I read with interest Spiro (2008) reflective account of knowledge transfer, whereby she cultivates her creative skills to explore her knowledge transfer theory through a story, conveying how authors invest emotion and philosophical participation:

> *'Story is also a resource in that from it emerge values, beliefs, patterns and assumptions which are revealed not only to the reader, but to the storyteller too'* (Spiro, 2008, p31).

Spiro (2008) emphasizes that storytelling is a fundamental process of action research and provides the difference between knowledge that was known to knowledge that was transformed into change.

Further discussions regarding my role within the project is discussed within chapters 6 and 7.

3.4 Methodology Considerations

Transferability of Literature

Learning is about knowledge, which is not the same as information; information is a set of structured signals that enter human consciousness through the senses; it is a message containing structured data (Cowan et al., 2000). The intention is to transfer theoretical knowledge into usable findings from a duality of both causation and methodology for management of indoor air quality; Thus providing OHS practitioners with competencies and data to effectively manage indoor air quality within their working environments. As mentioned within my literature review, the HSE and BOHS have limited guidance and engagement with indoor air quality matters; the project is intended to synergise information between parties and engage a common resource to centralise silo disciplines. A key component is the validity and generalizability in transposing theoretical literature into adapted and practical advisory capacity, thus ensuring effective transferability of data provided for the judgement of the user. To develop effective communication of user ability and persuasiveness throughout the text, an exploration of readership's complexity includes:

- Understanding the diverse audience;
- Understanding how the information will be read and adopted;
- Understanding the communication conventions within industry sectors;
- Understanding how a reader will respond to the text;
- Understanding the political, economic and social consideration than may influence transfer of knowledge.

Primarily the intention was to contour a framework for understanding the subject matter within the disciplines and explore opportunities to merge and cross fertilise such data.

I appraised readability formulas and whether scientific or technical writing is more objective than any other literature and how the consequences of a particular writing style may engender a deplorable attitude toward acceptance of text; the simplicity of the text affecting the academic appropriateness. Conversely the recognition that the fundamental rhetoric of technical writing may alienate a group of OHS and EH practitioners; compromising the meaningful notion of transfer of knowledge. Therefore, due to intended audience and ease of transferability of research, data findings within my thesis have been discussed in simple analytical terms. Parallel to the style, wording and conversation convention used within the text, attributing the various industries ideologies, the audience will also be influenced by their company's culture, local and personal beliefs, experience, knowledge, skill, emotions, demographics, culture and education, therefore the response of the reader will differ. Coney (2002) discussed how readers shape their acceptance of text by the willingness and independent existence during the reading process.

Coney (2002) recommended a fluid view of the audience with regards to usability of text. How a reader responds to the text, their perception, how the text will shape their personal stake in the communication is critical to the success of the programme and project activities, such as the IAQ website. The exploration of pedagogy will enable me to define my writing strategy and engage the reader with aesthetic writing. Rosenblatt (1994) describes an aesthetic reader as someone who is engaged and lives the experiences of the writer; such perception bestows a powerful persuasive tool for an author.
Thereby developing text that can offer more than just sectional text on a specific subject, but create an interwoven, business emphatic, OHS practitioner's guidance that enables the reader to assume a more multi-dimensional representation may assist them to construct their own meaning about the text and stimulate further studies.

Strategy for Dissemination

The dissemination is an objective in contributing towards raising the agenda of indoor air quality and thus it is important that the data is relevant, persuasive, understandable and acceptable. Considering Harmsworth and Turpin (2000) effective dissemination strategy tools, I reflected on understanding the content, stakeholders influence and effective methods of dissemination. Perhaps the most important question asked by Harmsworth and Turpin (2000, p2) is how do I know I have been successful?

Aside from the media chosen to disseminate, the most important factor is the objective of stimulating interest for the continuous discussion around IAQ, therefore an intended target audience is vital; considering those individuals/groups who are directly connected to the project, internal stakeholders and external parties, as illustrated in figure 9:

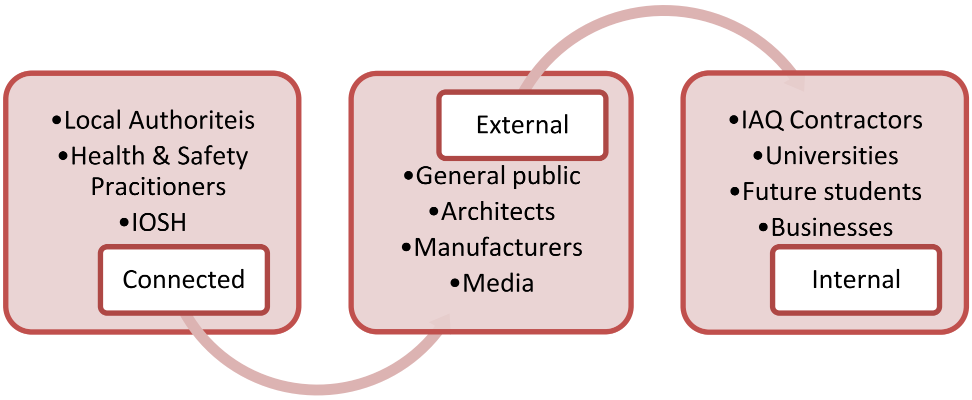

Figure 9: Dissemination Stakeholders.
Key stakeholders directly connected to the findings of the project.

Aside from the traditional publication of DProf work, I am intending to continue this journey and these discussions following the outcomes from this project, therefore reflecting and evaluating methods of dissemination will be critical for future aspirations discussed in chapter 7.

Evaluate Deliverable objectives

The framework for the website, training and competence standards must provide a solid framework to allow evolving development as indoor air quality gains momentum within industry's consciousness. A transactional model was used as a method for evaluating the expected outcomes and achieved outcomes, similar to the models used by McLinden and Trochim (2000) to explore educational value within a business context. I explore the deliverables throughout my findings chapter.

Ethical Considerations

LaFollette (1994) reminds us that researchers have been regarded as seekers of truth whilst obtaining new knowledge. Therefore the associated concepts of trust and accountability are correlated with knowledge and truth. Wells (1994) reiterates the relationship in terms of a code of behaviour appropriate to academics whilst conducting research.

The project actions and discussions of effective indoor air quality management have legal, social, economic, political, technological and ethical implications. Therefore, in accordance with the Management of Health and Safety at Work Regulations 1999 (HMSO, 1999), and Middlesex University's Ethical Committee a risk assessment was conducted to identify any significant hazards within the research. Ethical considerations inherent in the project included:

- All survey participants received an information sheet explaining the purpose of the study and their role as a voluntary participant;
- Due to the voluntary nature of participation, individuals were informed of their right to withdraw from the survey at any time and without having to provide a reason;
- All participants were over the age of 18 years old, no vulnerable adults were selected within the research. A consent process was used for both surveys;

- To avoid any bias reporting, no incentives were offered to participants; other than offering free advice after the survey for those seeking further guidance on IAQ. Such advice was strictly non-cost and no commercial services/products were offered during such requests;
- The survey questions were written in plain text, avoiding ambiguity and deception;
- Confidentiality of data collated and anonymity of participants; emails and website administration software were password protected, resulting in only my access;
- Any transcriptions of quotes from participants were considered to ensure no identification of individual participant, organisation and/or job role;
- The project was approved by Middlesex University's Ethical Committee.

With a work based project, the dynamics of the legal, social, economic, political and ethical consideration have a broader application. Aguilar (1967) originally termed the mnemonic of ETPS for the four sectors of his taxonomy of the environment: Economic, Technical, Political, and Social. Variations of PEST (Political, Economic, Social, and Technological analysis) and PESTLE (Political, Economic, Social, Technological, Legal and Environmental analysis) (Narayanan and Fahey, 1986) have since evolved. I have therefore incorporated the broader remit of PESTLE for my considerations.

Political

Potential Risks:

- Fracturing of IAQ interested parties, such as BOHS, IOSH, BIFM and HSE. With a lack of a controlling body managing IAQ policy and a lack of strategy structure in the UK, the existing organisations may withdraw from such activities to reduce potential public criticism associated with inadequate direction, resources and contribution.

- Sensitivity of publishing results the results from my survey and the potential criticism of the local authorities for failing to address a societal health risk and to implement the European Action Plan for IAQ management.
- Criticism of the local authorities for engaging in a perceived low risk activity, particularly at a time when resources are being cut.

Controls:

- Due to the diversity of organisations managing indoor air quality, the conflicting demands and strategies may cause discord with the project and result in isolation of organisations that have different aims, including commercial. Therefore sensitivity of communication and consultation should prevent such occurrences and maintaining confidentiality.
- Consideration of communication and potential outcome regarding findings within report to be sensitively handled, with consideration for understanding and discussing underlying reason and recommendations for compliance.

Economic Implications

Potential Risks:

- Potential costs to employers and contractor who review their existing IAQ arrangements to adopt recommendations for improvements.
- Reduction in number of competent occupational hygienists may result in higher service/consultation fees for employers.
- An increase of IAQ monitoring services offered by not fully competent contractors.

- As understanding of IAQ is heightened, association monitoring technology and instruments may increase in value/cost due to demand from consumers/employers, thus resulting in less accessibility of equipment.
- Increase of alternative training providers generating income from introducing their own IAQ courses; which reduces IAQUK attendees and ultimately increases the cost of running the courses.
- Alternative commercial companies advertising IAQ programmes, resulting in a reduction of IAQUK visibility..
- Loss of accreditation by IOSH, which impacts on IOSH's advertisement of the certificate.
- Failure to meet training needs of training attendees, poor delivery of certificate, affecting the credibility of the IAQUK objectives.
- Increase cost of running and managing the IAQUK website.

Controls:

- Highlighting the importance of measuring indoor air quality can stimulate an appreciation for a cost effective model to recognise impact and potential losses for not managing economic value and profitability of good indoor climate.
- Continuous development of IAQUK as a brand for the delivery of independent advice and training of IAQ matters.
- Training evaluations used by delegates to understand content and delivery of course and whether the certificate met their needs. Training courses attended by an IOSH training verify to monitor course activities.

Social Implications

Potential Risks:

- Negative impact on health and safety risk perception. Whereby the media perception of health and safety is negative and additional guidance could be perceived as additional restrictions for business owners.
- Impact on employer's IAQ management controls. It is not the intention for an employer to remove existing ventilation and replace, merely to monitor and control such activities.
- To inform the public about indoor air quality may create a severe response and potentially cause industrial conflict with employers concerning parameters of comfortable conditions within the workplace, or housing organisations (private and public) suitable home environments.
- The application of good ventilation is often associated with the design of the building and the type of ventilation and therefore such fixed structures may impinge an employer to undertake direct action.

Controls:

- Sensitivity of consultation and clear messages provided for society to ensure sensationalising does not occur within the media.
- Implementation of influence, as opposed to legislation rationale for applying good IAQ models within business.

Technology Implications

Potential Risks

- Due to the increase awareness of IAQ, social and commercial internet sites may increase offering advice and commercial solutions to tackle IAQ, with the potential of misleading stakeholders such as the public and local authorities.

- Incompetent individuals undertaking inaccurate measurements, particularly those individuals who are commercially selling a service.
- Introduction of products with increased technology risks, such as UV ozone lamps incorrectly installed within HVAC.
- Commercial websites using my project material within their commercial promotions to sell IAQ services/products.

Controls:

- The introduction of a free website portal within my project activities will ensure accurate material is accessible to interested parties without cost or commercial gain.
- The website to include information links to bodies such as the BOHS to source a suitable occupational hygienist.
- Search activities across key search engines sourcing my name and activities to be regularly undertaken to protect my reputation and work.

Legal Implications

Potential Risks:

- Negative impact on health and safety risk perception. Thus the perception of risk could impact actual risk. Although the intention is to raise the agenda of IAQ, there is no intention to do so at the cost of severe risks, such as confined spaces, working at height etc.
- Civil claims for organisations failing to meet foreseeable standards. Whereby buildings failed to meet IAQ standards, the potential of a civil claim could emerge, but only if a direct correlation could be demonstrated between IAQ and losses.

Controls:

- Setting guidelines or standards for indoor air invoke difficult issues. In particular the acknowledgement that quality of indoor air is submissive to hazardous toxins that generate chronic health effects.

- Therefore gaining preconisation for the importance of good air quality, without stimulating the resistance to ‘nanny state’ impositions, will create challenges.
- Moreover, the concept that health and safety plays an important part in the economy of productivity and performance of employees, thus demonstrating an effective business case of reducing accidents and ill health.
- Consideration for the implications of highlighting the agenda and potential legal implications for those environments that do not meet the standards or indeed existing OHS consultants/practitioners that do not meet the competencies for service offerings.
- Germany has experienced negative responses to indoor air quality standards because of problems connected with the litigation issue; however it is not expected that such litigation should occur with IAQ.

Environmental Implication

Potential Risks:

- The impact on climate change and the requirement to increase energy efficiency and protect against heat loss will continually challenge the IAQ agenda, particularly as technology and building designs evolve to meet such requirements.
- Incorrect advice via the website or training, resulting in an increase risk to occupants.

Controls

- Engagement with all parties within the IAQ agenda, including environmentalists, architects and facilities management would negate ignorance of such risks.

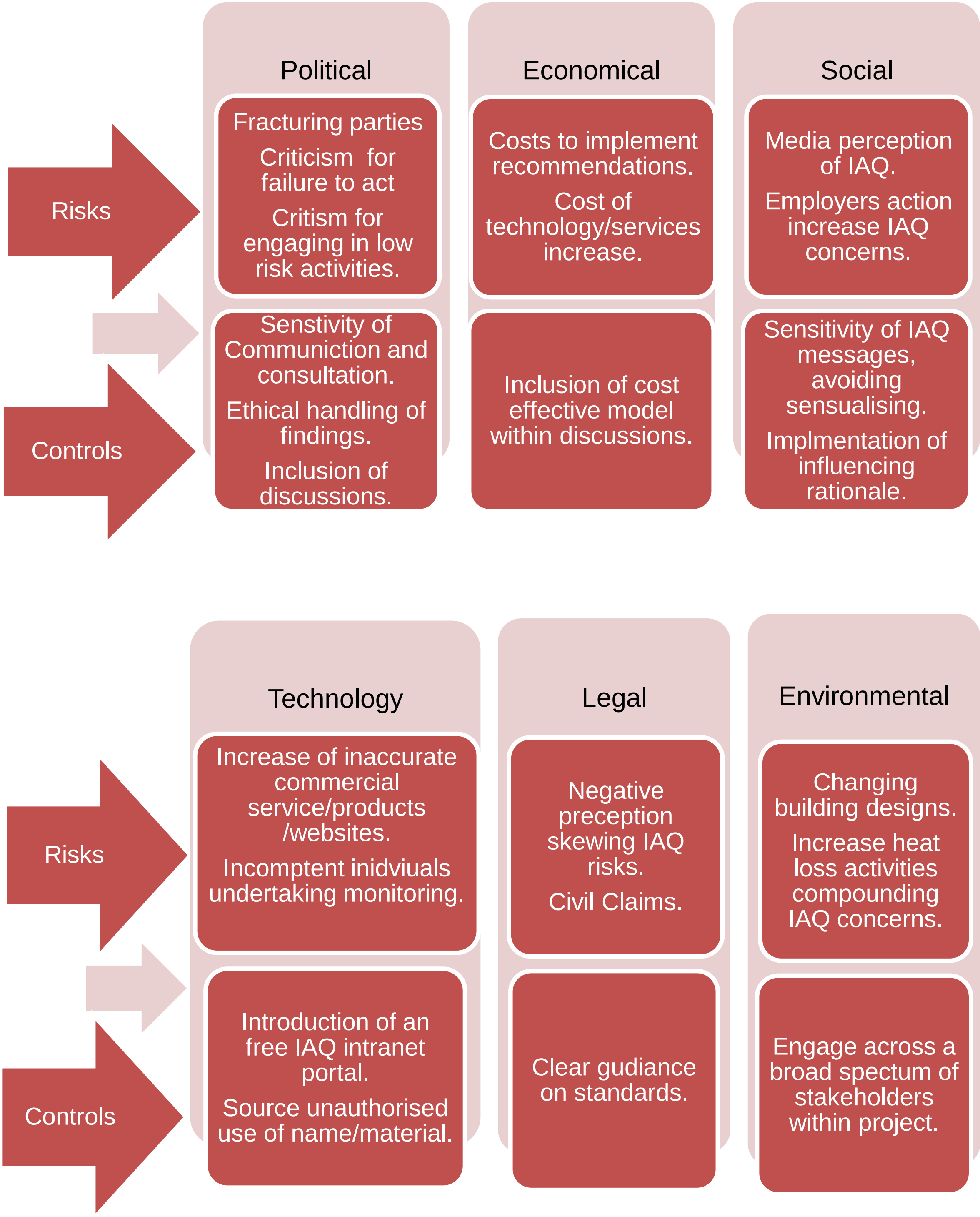

Figure 10: PESTLE summary.

An illustration of the political, economic, social, technological, legal and environmental ethical consideration for my project.

Summary Ethical Implications

An illustration of PESTLE is represented in figure 10, page 152.

Potential Risks:

- Discrediting of my research. I am particularly cautious to demonstrate there has been no individual financial benefit from this project.
- Discrediting accredited training provided. Ensuring the training is not seen as a personal commercial gain.
- Skewing of data, as views presented are either an official view from the organisation or an emotive view from an individual.
- Bias and ethical risks from my role as an insider researcher; ensuring my passion to raise the IAQ agenda does not result in narrow and misleading view of IAQ.
- Due to the large complexities of IAQ and the broad stakeholders within, it is important to understand the limitations of my role and the need to engage and incorporate existing academic, technician, practice and government bodies within activities.
- Constraints on my time to deliver the project within the programme plan, particularly with increasing challenges within my role and the competing demands of working within a global position.
- Costs for my project were minimal and aside from a negligible fee for me to register a domain name, host a website and the occasional costs of travelling to Leicestershire to deliver an IOSH CPD certificate.

- Throughout my project I have been particularly concerned regarding the requests to partake in commercial activities or to sponsor my work for commercial gain. Indeed I have read unauthorised quotes from my work, naming me as an individual on commercial material, which subtlety indicates I am endorsing a service/product and therefore proactive action will be taken to reduce such incidences.

Controls:

- The introduction of a OHS practitioner's awareness certificate with one training organisation may be seen as competitive advantage and merely a commercial gain, as opposed to delivering national competency standards.
- Therefore the underpinned knowledge will be consulted across the key stakeholders with a view to accreditation by a national training body that already has a structure for managing approved trainers. This will ensure that the course will be available across the UK.
- I do not intend to provide technical guidance on design, installing or maintenance of HVAC systems or propose my course replaces existing technical qualifications for technicians. It will be positioned as an awareness course for transdisciplinary OHS practitioners.

Following an evaluation of the implications, there are negligible health and safety risks. The assessment review remained 'live' throughout the project to ensure any dynamic hazards that were identified could have been and incorporated into a new risk assessment. Provisions for any liability interests on behalf of any advice or guidance given, I have transferred insurable risk with Professional Indemnity Insurance cover. The underlying theme of this project is the application of research into a real world situation, and therefore attention to PESTLE ethical implications is critical.

In addition to Middlesex University's Ethics Committee, I also consider Winter (1996) discussion principals, in particular:

- Ensuring relevant persons and authorities have been consulted of the project in advanced;
- All participants had an opportunity to provide further comments to shape this project;
- All participants had the opportunity for further guidance from this project to assist with developing their own IAQ agenda.

I am passionate about the delivery of IAQ and therefore wish to ensure information generated throughout this programme is accessible with both raw data and dialogue to assist organisations and authority bodies to understand actions required to meet IAQ standards; Such free support and resources was made available to all participates.

Whilst debating PESTLE application of my DProf, I also considered the application when evaluating positive change management of IAQ, as illustrated below in figure 10. PESTLE has been an interesting tool to define such benefits.

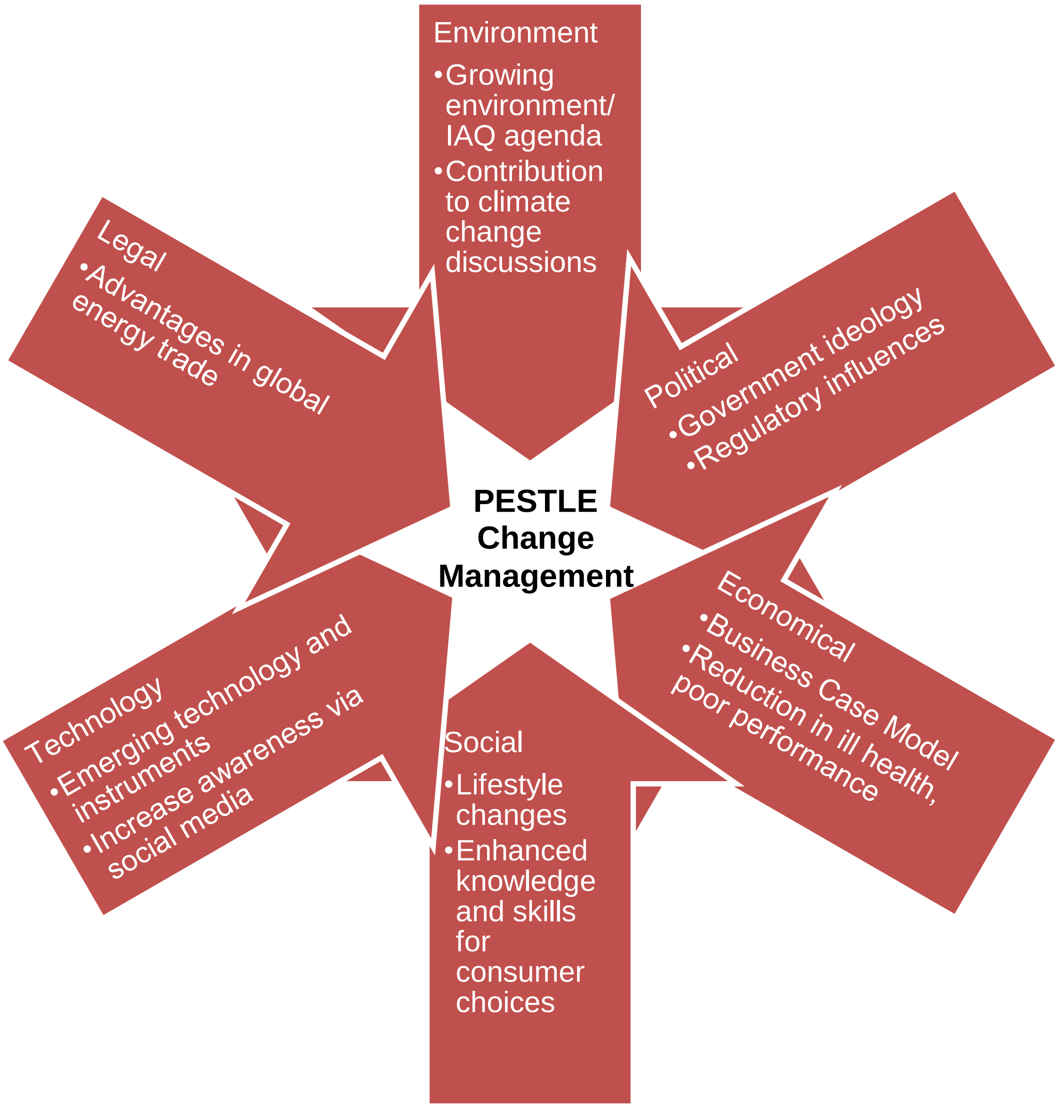

Figure 11: PESTLE Change Management

Application of PESTLE as a change management model

The diagram in Figure 11 provides clear benefits of IAQ, conversely a risk to IAQ management, such as increasing visabilityin the social media, can be a benefit by increasing society's understanding and engagement with IAQ. I have explored some of these thoughts within my discussion chapter, page 271.

3.5 Conclusions

Chapter three provided an overview of the methodologies explored, discussions regarding chosen methodology and the journey as a researcher within the project. Chapter three clarifies the mixed methodology approach using quantitative and qualitative data, triangulation of literature and survey data, change management and an underpinning application using PESTLE.

Throughout my project I found difficulties in developing a structured, rigid methodology, as my inquisitive ethnographic approach to exploring the application of IAQ created uncertainty in my direction and stimulated many redrafts of my project aims and objectives. A clear epiphany for me arose within action research, whereby I started to accept and embrace the journey and become immersed in my project. This is quite opposed to a traditional approach to a research project and therefore by structuring my immersion and the personal feeling of comfort with this approach, using action research and reflection, allowed for more freedom to explore and create a direction.

By using action research, I have been able to shape my project, I have discussed the cycles in chapter 5.6, page 257.

The critical aim is the transferability and change management of IAQ, traversing silo topics and stakeholders, skewed by government reports, disparate resources, reinforced by the paucity of application to a real world environment and sparse evaluation of a changing society; such freedom and absence of rigid approach enable a depth of understanding in a real world environment. Navigating my own swamp of unknowns (Schon, 1983) I found a layering approach to my methodology shaped by my literature research, surveys and activities such as triangulation.

Unlike the traditional application of selecting triangulation to validate my findings, I recognise there is no final conclusion, merely an organisation of thoughts to bridge a silo debate into a more coherent topic, with intentions to stimulate further dialogue.

Stake and Trumball (1982) describe the insights gain through reflection as naturalistic generalization. Throughout my thesis, generalizing findings from my research, literature review and findings from my project activities have constructing interpretive reflection and understanding. Melrose (2009) describes the goal of naturalistic generalization is not for researchers to prescribe conclusions. Melrose aligns the reader with the responsibility to apply the details within their own environment and experiences.

Allowing a naturalistic generalization approach that overlaps variances and highlights gaps in the knowledge of IAQ has provided a contextual analysis to enable me to reflect throughout this project and draw a conclusion of recommendations for future research.

Such organic application can skew the direction of my DProf project and therefore I used a structure of action research as part of my methodology to enable a coherent collection of thoughts that have an inclusive factor within my project. I also included a framework for active learning to ensure extraction of lessons were included to new knowledge through reflections and experience which is considered as an organic process throughout the project.

Diary developments and self-learning was employed as a method of reflection and a critical appraisal of the project, as discussed on page 310. Reflection has been included as a key component within the timetable to ensure a critical evaluation of my work, methodology and interpretation of findings.

An integral application of using triangulation data is to provide a rich context of findings. The journey of this DProf research has refined my skills within experiential learning (Kolb, 1984) and reflective practice (Schon, 1983) representing learning as a cycle.

The intention was to transfer theoretical knowledge into usable findings from a duality of both causation and methodology for management of indoor air quality; Thus providing OHS and EH practitioners with competencies and data to effectively manage indoor air quality within their working environments A further consideration for including value of action research is recognising the broad scope of IAQ discussions and the limitation to include all dialogue, therefore by providing an open account of actions and reflective points, further research can be cultivated.

A clear clarification is my role as a researcher and a practitioner in a real world environment, managing the complexities from the triple helix model, as discussed on page 27. An afflatus of action research is the understanding that knowledge and experience provides value to me as a researcher (developing new knowledge from alternative sources) and value from me as a researcher (experience and competencies applied to the project). The chapter has enabled me to explore the various methodologies and evolve my project to provide clear structure and direction for project activities and discussion. It has also facilitated my identity as an insider researcher and appreciation of the limitations of my knowledge within this field. This reflection has enabled me to consider my future positioning in understanding what unique differences I can bring to IAQ via the transdisciplinary communities and the exploration of raising the agenda of IAQ.

Through action research the methodology has also assisted with refining the aims and objectives of this project. The chosen methodology allowed me to become immersed in the IAQ arena without losing direction of my rationale and direction of the project. The methodology provided a practical application to consider transferability of the findings into practical application.

Translating qualitative data and the diverse, complex and nuanced approaches (Guse and Guse, 2010, p2). a thematic analysis was used which encouraged an active role in identifying themes and emerging concepts as discussed within my findings in chapter 5. Open and available data is essential to demonstrate transparency, to enable individuals to challenge your hypothesis and encourage contributing research to current findings. Therefore histograms are published and individually discussed later in chapter 5 and within the appendix, for each question, accompanied with the raw data to support future studies and discussions; a standard mean table is presented with each discussion. A linear plot is used for some questions with the intention to evaluate relationships amongst pairs of variables. The ethical considerations were to ensure the project did not create a risk or negative impact, due to the breadth of the project, I considered PESTLE (Political, Economic, Social, Technological, Legal and Environmental analysis) as the most appropriate tool for evaluation. Due to the political climate of risk aversion within our society, the IAQ project could be seen as another nanny state adoption or a commercial venture for organisations. As described throughout my project, I am passionate about the delivery of IAQ and therefore wish to ensure information generated throughout this project is accessible with both raw data and dialogue to assist organisations and authority bodies to understand actions required to meet IAQ standards. The development of this project and further research following my DProf must remain visible to ensure we as a society balance such social risk with long term benefits and solutions.

Throughout Chapter 3 I have defined my methodology and the philosophical approach in using my knowledge and experience to immerse into the subject. The success of my project is embracing this approach, using action learning to shape my direction on how to navigate uncertainty, skewed data and lack of resources to truly provide value to my project. In chapter 4 I will be triangulating this data to discuss my two transformative project activities, IAQ accredited training and an IAQ website.

Chapter 4 – Study Activities

4.1 Introduction

Within Chapter 4 I discuss the approach to my initial project activities of developing two transformational applications of IAQ into a real world situation, as shown in figure 12 below. The literature review and research activities enabled me to gather information and identify gaps within IAQ knowledge, with the intention of triangulating with existing literature research to develop two platforms:

- Development of the first UK IAQ accredited training certificate;
- Development of the first UK's dedicated IAQ website.

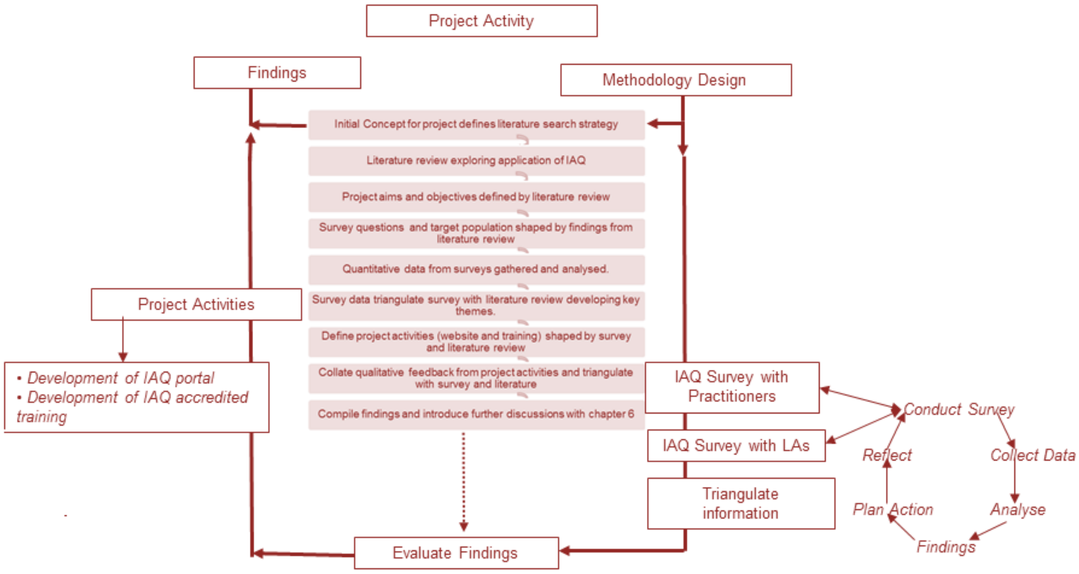

Figure 12: Extraction from figure 7.

Helicopter view of project activities, extracted from figure 7 schematic.

The literature review and the OHS practitioner and local authorities' survey have provided steerage for the development of an IAQ website and training certificate, using action research as the chosen methodology, as discussed within this chapter.

4.2 Development of IAQ accredited training

Introduction to IAQ accredited training

The literature review and research activity has enabled me to harness sources from academic and non-academic channels and provide usable knowledge. As discussed within previous chapters, an underlining theme of my DProf is the transformative application of IAQ. Thus my doctorate is not only concerned with knowledge, but the ability to create effective change with the intention to develop a platform to continue contributing towards the growing agenda of IAQ. To develop usable knowledge in actual change, I have included within my project two activities:

- Development of the first UK IAQ accredited training certificate;
- Development of the first UK's dedicated IAQ website.

The intention is to develop understanding and motivation for IAQ and provide a continual accessible source of information. The evolving changes to our working environment, the context of work, the workforce and nature of work and the products and building structures combine to present a real challenge to IAQ, a challenge that is dynamic, ever-changing, contingent upon the character of the economy, political wiliness and understanding and society risk perception; such challenges require the competence and skills of transdisciplinary professionals. I therefore considered the following criteria:

- What competencies would be expected for an IAQ practitioner?
- How should the project address the multidisciplines of OHS practitioners and previous knowledge/skills?
- How do I incorporate expertise from multiple disciplines?
- How does the project contribute towards the emerging agenda of IAQ?

I consider that the sheer magnitude and complexity of these questions are, in part, responsible for the limited progress made towards the development of a core curriculum in IAQ and the expansion of IAQ education in the UK and across Europe. In addition to the exploration of knowledge, I have considered that competencies must also meet the requirements of Government and organisational needs.

Developing Sinclair's (2006) model of challenges in Occupational Health Practitioners training programme development (stakeholders, core knowledge and multi-disciplinary dilemmas) I have considered this application for an IAQ training programme within figure 13:

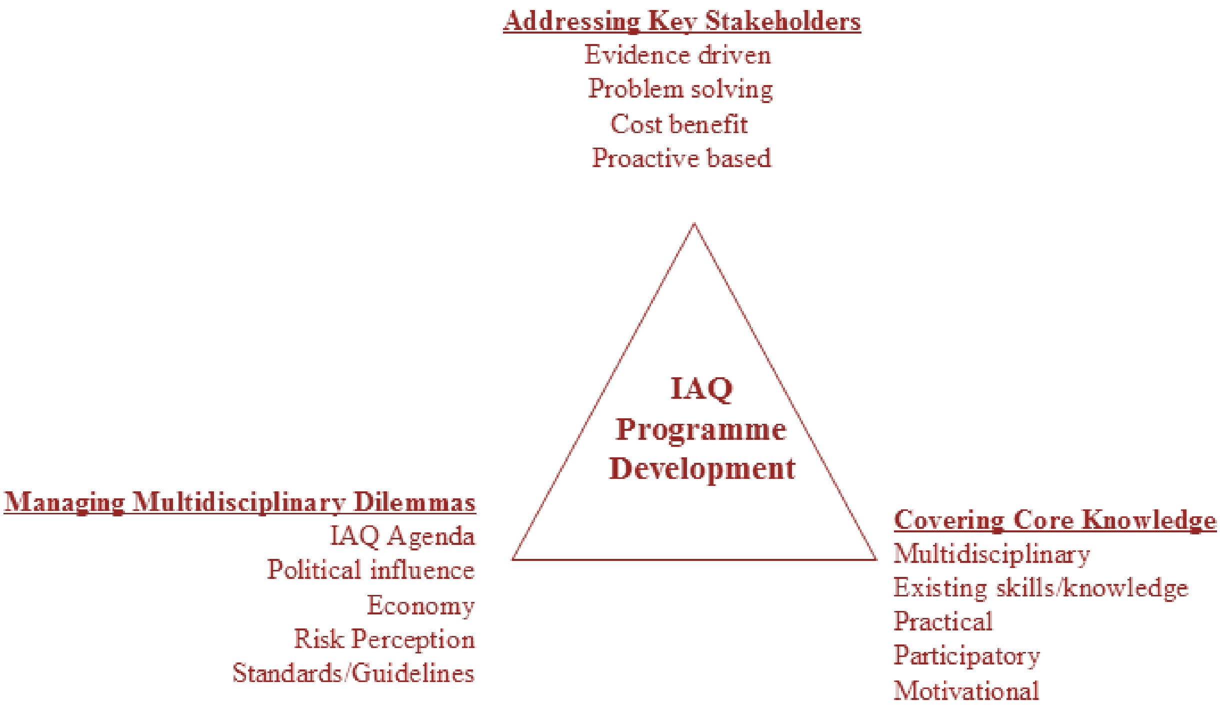

Figure 13: Model to address IAQ training requirements.

An evaluation of key stakeholders, core knowledge and multi-disciplinary dilemmas for the IAQ training certificate.

The curriculum must reflect the inter-disciplinary silos of the subject, it is important that it addresses a range of broad topic areas with an emphasis on interdisciplinary perspectives (Chen & Hammer, 2006). Therefore a theoretical critique of existing IAQ syllabuses, websites and content enabled a gap analyses within my literature review to identify underpinning knowledge and secondly identify key expected learning outcomes and understanding of targeted students. Influenced by Schon's (1987) notion that knowledge informs practice which generates further spirals of knowledge, a work based learning mode would have been preferred to ensure a transdisciplinary criteria had been achieved.

Raelin (2008, p67) discusses work-based learning by comparing theory and practice modes of learning, and explicit versus tacit forms of knowledge. Explicit knowledge delivered in a conventional form of a lecture, whereby explicit knowledge might be represented in the user engaging in air quality sampling and data analysis. Raelin (2008, p79) further discusses the three critical elements in work-based explicit learning that differs from conventional education, learning is acquired in the midst of action, knowledge is a collective activity and users develop a learning-to-learn aptitude. Silberman (2006, p41) underpins this view by suggesting that content is not as important as learners understanding the value of the information being transferred.

Development and Placement of the IAQ Certificate

No progress has been made towards an IAQ training course in the UK in spite of the undeniable importance of raising the agenda through certification and the attendee's benefits of the discipline that it would bring. This is understandable in view of the complex range of barriers that are required for the ownership of developing and delivering the training.

Due to the broader knowledge and competencies of stakeholders, it is also apparent that one course would not fit the needs of all parties.

There are several routes to developing a programme:

- Existing degree courses that could incorporate IAQ;
- Existing continuous professional development programmes (CPD) offered by established institutions that could accredit the course.

Many of the Environmental Health degrees are influenced by the Chartered Institution of Environmental Health (CIEH) and therefore harmonisation between the existing CIEH's objectives and that of the individual universities would be considered. The potential of addressing further multi-disciplinary stakeholders, such as engineering, health and safety, building design for a contribution to an integrated degree programme will further stimulate interest and drive motivation for the topic. I have discussed the potential of integrating IAQ into degree programmes within chapter 7 page 319.

The last decade has witnessed an increasing focus, both in research and in the policy debate on continued professional development (CPD) and work-based education and training, as instruments for enhancing productivity, competitiveness, and economic growth. IOSH have embraced this approach with the introduction of CPD accredited membership scheme. Therefore the proposal to introduce an IAQ awareness CPD certificate would require consideration to complement existing competencies from IOSH certificates and degree programmes, thus extending professional development skills of existing OHS practitioners. The accredited certificate would also contribute towards the credits for OHS practitioners, enabling them to maintain their continuous professional development (CPD) skills/knowledge as required by IOSH.

The development of an awareness course will endeavour to raise the agenda of IAQ within the transdisciplinary community of OHS practitioners. Using my own knowledge as an insider researcher, I would be able to navigate the existing structure to influence a new topic within the OSH professional field.

The purpose of an awareness course is to stimulate interest and further learning from the students. The attributes continuous professional development Campbell et al., (2010) describe as a process, as opposed to a static set of learning competencies.

They summarise that this self-directed journey is subject to five criterions:

- Use practice information to identify learning priorities and to develop and monitor CPD plans;
- Access information sources for innovations in development and new evidence that may potentially be integrated into practice;
- Establish a personal information management system to store and retrieve evidence and to select and manage learning projects;
- Construct questions, search for evidence and record and track conclusions for practice;
- Use tools and processes to measure competence and performance and develop action plans to enhance practice.

Lord et al., (2010, p381) draw a parallel between lifelong learning characteristics and those of self-directed learners, such as being curious, motivated, reflective, analytical, persistent, flexible and independent. It is intentional that the certificate will not just provide an acquisition of knowledge, but a stimulation to engage further within these diverse topics, to ensure retention and reflection on the subject matters and practical application and provide training that traverses from theory into a practical setting

Laal (2012) aligns societal notion of improving human potential and development with lifelong learning. There is subtle tone of Laal that indicates lifelong learning can improve our society and environment.

Therefore I considered IOSH as the most suitable body to accredit an IAQ certificate, due to the existing credible CPD training structure in place and their interest in developing new topics within their programme. To engage a conversation with IOSH, I developed a training proposal for their CPD training team, with the intention of the tender to:

- Describe the rationale for the IAQ programme;
- Determine the best method of delivery;
- Define learning outcomes;
- Provide details regarding content.

The engagement with the training team took approximately 18 months from initial proposal to acceptance of the course, which was attributed by my ability to persuade and promote the agenda of indoor air quality. IAQ does not fall easily with the various institutions and IOSH voiced concerns about whether such a topic would sit within its remit. Petty and Cacioppo's (1981) model called Elaboration Likelihood Model provides a helicopter view of understanding the flow of effective persuasion techniques. The model provides persuasive context that induces change via either a central route (reliant on the direct persuasive communication) or a peripheral route (influenced by environmental characteristics such as credibility, quality of message). For a holistic approach, peripheral provides context to my message and using my desire (Petty & Cacioppo, 1979) and ability (Petty, Wells, & Brock, 1976) I was able to navigate the persuasive model.

I have reflected on this model to understand the flow of conversation with IOSH within figure 14, page 168.

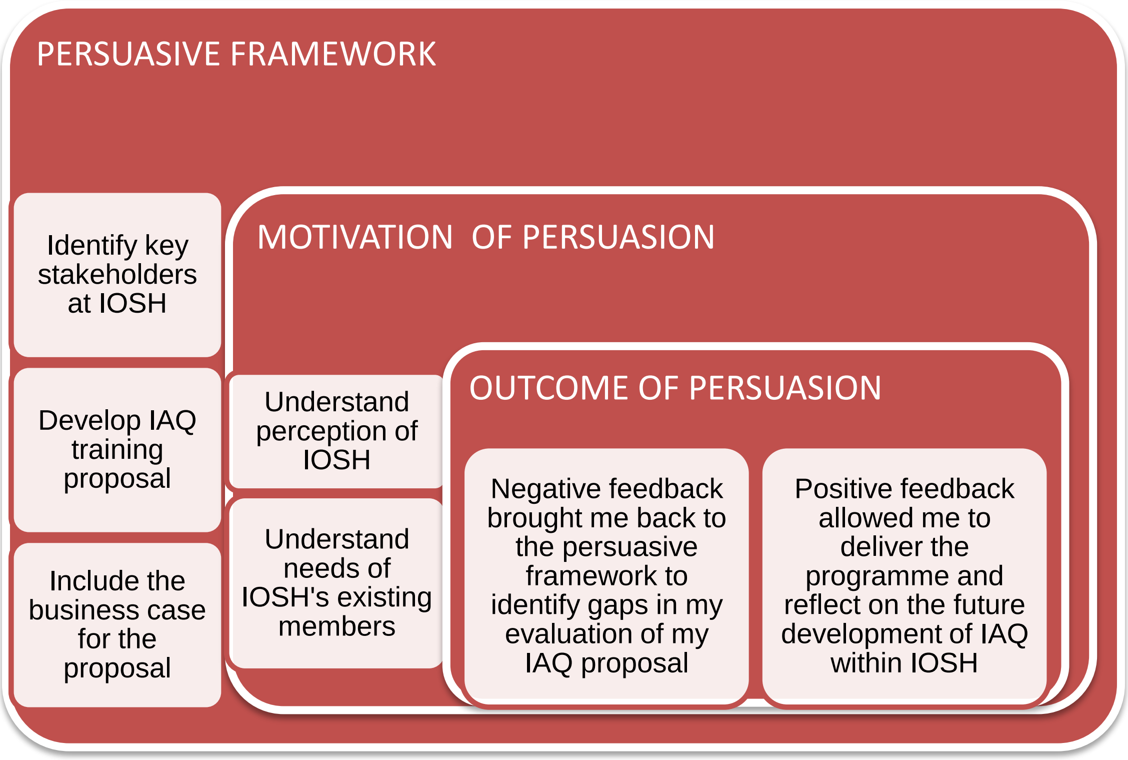

Figure 14: IAQ persuasive reflection model.
A reflection of the persuasive model, evaluating motivation and outcome for influencing IOSH to engage with an IAQ certificate.

A proposal, accompanied with the training material was prepared for further discussion. The proposal included a synopsis of the course, with the learning outcomes, contents, structure of delivery and method of evaluation. To encourage debate, I proposition distinguishable features of the certificate:

- Offering UK IAQ best practice knowledge and guidance;
- Demonstrating linkage between IAQ and productivity and performance;
- Providing practical, unambiguous advice for non-technical OHS practitioners;
- Supplement with current research for further reading;
- The only UK comprehensive training programme for IAQ with modern theories and practical applications.

Due to my current practitioner's experience of writing and delivering training programmes, I had a clear vision of the structure, delivery and evaluation of the certificate. The most challenging aspects of this project was the engagement with IOSH to persuade the training team of the advantages of including a CPD course within their established programme. Again reflecting on my practitioner's skills of working within a commercial environment, I used a structured approach to discuss the rationale and uniqueness of the certificate. Consciously I referred to my leadership module and reflected on models of influential behaviour, such as Kanter (1985) who suggests the crucial importance of leaders to be change agents and that all leaders must develop an understanding and high degree of competence in creating and managing change . Kotter (1996) describes an effective leader as someone who gathers a broad range of data and looks for patterns and relationships to be able to create a vision and strategy.

As Yukl (1998) identified:

> *'A variety of different influence processes may be involved in transformational Leadership*' (Yukl, 1998, p328).

The varied transformational leadership models comprises four key areas (Yuki, 1998, p276) inspirational motivation, idealized influence, individualized consideration, and intellectual stimulation (Burns, 1978; Bass, 1985), Burns (1978) cast leadership as action uniting leaders and followers in the pursuit of significant and morally desirable change. And Bass (1990) used the term transformational leadership to describe inspirational leadership wherein followers are elevated and empowered. Lowe et al., (1996) confirms these views, stating transformational behaviours as highly effective leadership skills. Often such transformational models describe charismatic leadership which Conger and Kanungo (1998) discuss as the application of shared visions (p54), motivational (p51) and emotional arguments for the change and a healthy dose of optimism and enthusiasm (p55).

With my passion for raising the subject matter, I used this influential aspect to meet with IOSH to discuss and debate the benefits of the IAQ certificate. I found my meetings were more effective than structured proposals and remote communication (emails and telephone calls). Face to face enabled me to provide dialogue and authentic narration of my knowledge and passion for IAQ; Sparrowe (2005, p420) characterizes narrative process through which:

> '*Individuals interpretively weave a story uniting the disparate events, actions, and motivations of their life experiences'* (Sparrowe, 2005, p420).

Kouzes and Posner (2002, p50) frame the journey to authenticity leadership in terms of finding one's voice:

> '*Finding one's voice and aligning behaviour with one's values engenders credibility in the eyes of followers'* (Kouzes and Posner, 2002, p50).

Therefore the value I provide as a leader of the project is more than technical, my role is to inspire and lead the agenda to stimulate debate. Such application is weaved into my training, but this raises questions regarding how this can be achieved at a national policy level?

Syllabus

Schulte et al., (2004) illustrates the simplicity between three functions, knowledge created, knowledge transferred and knowledge utilised whilst appraising occupational hygiene training, depicting a cycle whereby the three functions of knowledge are interlinked.

Schulte et al., (2004) recognised that knowledge can be fed forward through this model when new competencies is learnt from knowledge transfer or utilisation, thus suggesting that proficiencies are dynamic and does not necessarily have to follow a linear relationship with the model. Therefore within my own IAQ training certificate, it is important that dialogue and workplace learning is applied, allowing for exchange of thoughts and ideas to develop the training content further.

Knowledge Creation

As previously discussed I critically evaluated the IAQ certification programme by the American Council for Accredited Certifications (ACAC) to explore typical type of content and method of evaluation. As the UK version is initially designed as a one day introduction to IAQ, I decided to streamline the topics to suit the audience and timescale. On page 98, I discuss the appraisal of existing IAQ syllabus, websites and content. The gap analysis enabled me to identify underpinning competencies and identify key expected learning outcomes of targeted students.

To commence the training certificate, I developed a syllabus to outline the contents of the course, expected learning objectives and grade required to meet objectives. To begin this process, I used the details from my literature review to define key learning outcomes, which were divided into 8 sections of a one-day training course, as illustrated in figure 15, page 172.

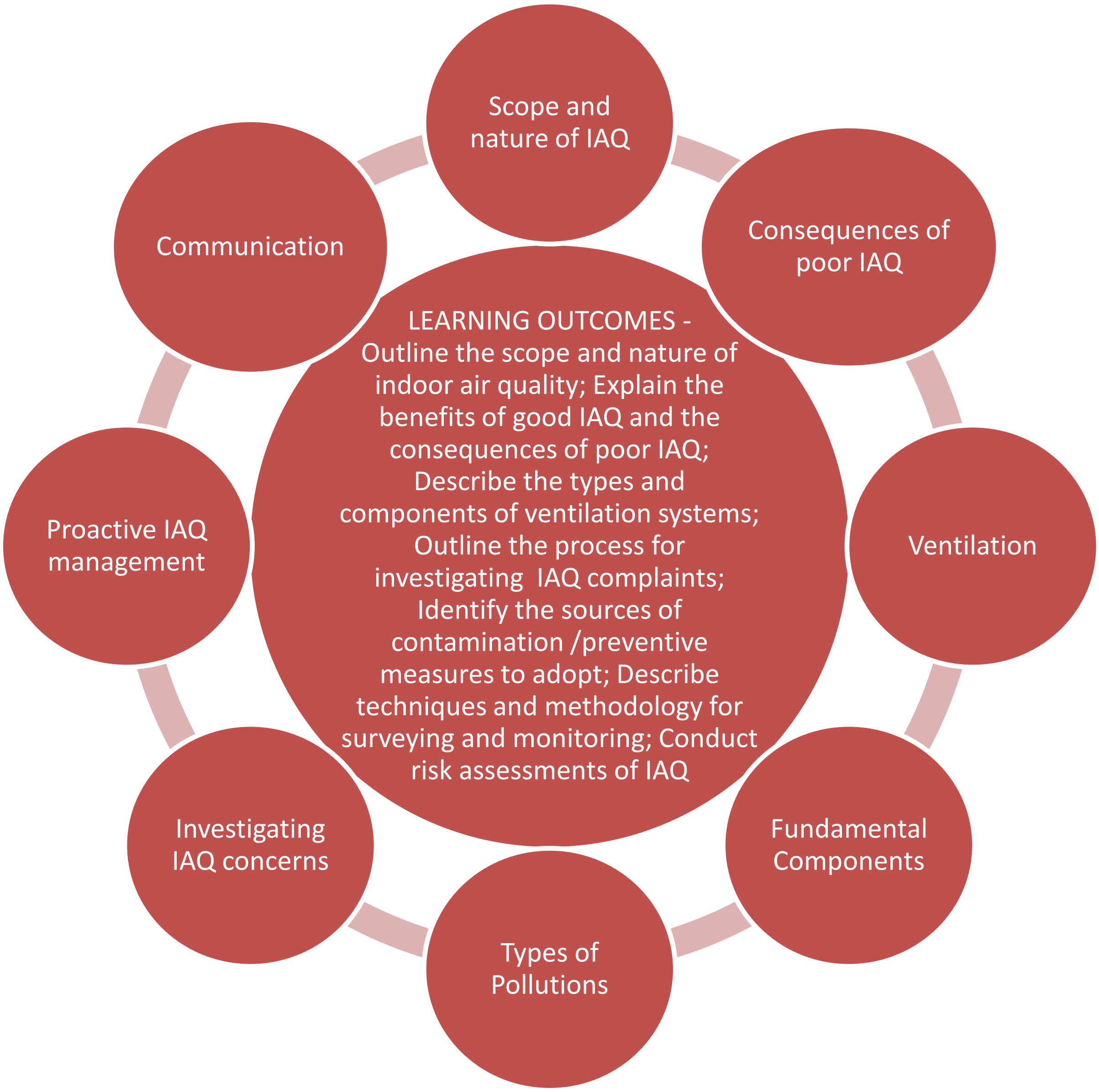

Figure 15: IAQ Certificate objectives and course content.

Visual overview of IAQ course learning objectives divided into eight section.

I viewed the syllabus with four key factors:

- I would consider the syllabus as a tool for motivating interest in IAQ; a dedicated certificate provides visibility and identity for IAQ, as opposed being hidden within associated subject matters;
- A syllabus can assist students to identify their existing competencies and understanding (Pastorino 1999) and how the IAQ certificate can enhance their knowledge, therefore pre-course information is provided for the students.

- This is particularly powerful within the IOSH's CPD programme whereby similar courses such as COSHH and Local Exhaust Ventilation (LEV) certificates. O'Brien et al., (2008) discusses how a syllabus can be used as a reference document during and after the training, thus assisting with knowledge transfer.
- The syllabus can serve as a historical document that can be developed for future courses.

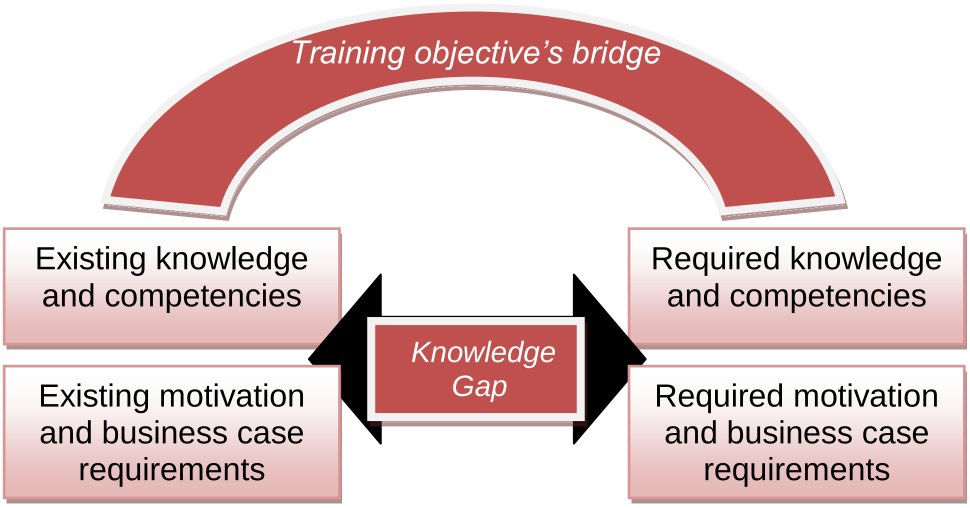

Figure 16: Outline of bridging knowledge gap

Using a syllabus can assist to structure and bridge the gap between existing knowledge and motivation and required knowledge and motivation.

The training slides were developed on the knowledge I had gained through the literature research. Reviewing pedagogy methods I referred to literature regarding the design and layout of the training programme, Clark and Lyons (2010); Daniels et al., (2007); Wink (2010); underpinned with Keller 1979's model of motivation, performance and instructional influence, as discussed on page 104.

I had also consulted with IOSH's training team during the development of the material to ensure the content was a correct standard for existing CPD courses. In addition I tested some of the material whilst lecturing for Middlesex University Environmental Health degree students, which I had received positive feedback regarding the sessions.

Knowledge Transfer

To facilitate cohesive training, I had considered the type of participants suitable for the certificate; the certificate was aimed at existing health and safety professionals, occupational health staff, occupational hygienists and managers with building responsibilities. No previous knowledge required, however a basic understanding of COSHH would be an advantage. The objective was to influence importance as well as provide theoretical knowledge.

The certificate was delivered using a variety of methods:

- Classroom style with PowerPoint;
- Study resource pack;
- Graphics (depicting airflow movement in a room, ventilation mechanics);
- Video clips of IAQ equipment monitoring;
- Audio of occupants testimonies explaining their health and comfort symptoms;
- Picture of office indicating sources of contamination;
- Monitoring equipment demonstrated during certificate;
- Case studies;
- Example IAQ reports.

Knowledge Utilisation

Utilization of knowledge is intended for OHS and EH practitioners to influence decisions on building design, monitoring activities, promote awareness and manage IAQ risks.

It is difficult to appraise utilisation of knowledge by the students who attend the training certificate; however, as the trainer I have maintained email contact with all the delegates to enquire their progression and use of knowledge. I have discussed this matter further within my findings chapter.

Implementation

The certificate was introduced into IOSH's CPD programme in October 2010, with course dates set for 3 sessions a year, with the intention to expand the one day course to two days in 2013/14.

Delegates who attended and successfully completed their examination could claim credits for their Continuing Professional Development (CPD) as a member of IOSH. A copy of the course syllabus is included within appendix 13, page 430.

The courses were held at the IOSH training centre in Leicester and were advertised by IOSH to all their members via email and their website. The course was also included within the CPD training brochure. IOSH managed the pre-course information and course evaluation processes. A full copy of the syllabus, examination questions and slides is included within the appendix 11, 12 and 14, pages 422, 425 and 431.

In addition to the examination to test student's knowledge, the certificate was also evaluated by a member of IOSH CPD training team on the first session to ensure appropriate delivery. In addition, students are asked by IOSH to complete an evaluation of the course content, delivery and trainer after each training session.

Evaluation of the certificate and findings from delivery are discussed within chapter 5, page 196.

4.3 Development of IAQ Website

Structure to review IAQ Website

The proposed website offers transferable information to OHS and EH practitioners within safety, facilities and building design and a resource for lay readers (interested in chemicals in the home, effects of perfume) with the following distinguishable features:

- Offer UK best practice and guidance;
- Demonstrates linkage between IAQ, productivity and performance;
- Provides practical, unambiguous advice for non-technical OHS and EH practitioners;
- Supplements with current research for further reading.

Essentially the site will be written for a non-technical OHS and EH practitioner and will be as the central resources site for IAQ matters. The site provides the reader with practical guidance on how to achieve effective air quality in the workplace and home for optimum conditions. It explores the methods used to identify, assess and monitor the efficiency of ventilation systems and will outline legislation and best practice for HVAC. It contains UK legislation; however practical aspects and the application of best practice is global. The site will incorporate a comprehensive melange of technical disciplines which will assist the reader to transfer technical information to practical application. The site contains further reading, to include global academic references, thus providing a reference for health and safety and environmental students with the intention to provide material that can be used as preferred reading resources with Universities.

During my research, I conducted a trend analysis on indoor air quality published on Google to understand the impact the internet as a medium can influence.

Although not a traditional resource, I have decided to use Google for trend analysis as it represents a universal form of communication within a modern society.

> '*The Google search engine indexes around ten billion pages on the web today*' (Cilibrasi and Vitanyi, 2001, p2).

Google Trends can be located on www.google.co.uk/trends/. Google Trends analyse Google web searches to compute how many searches have been entered for the pertinent term, relative to the total number of searches done on Google over time. The results are then shown on a graph, plotted on a scale from 0 to 100. The normalised graph, figures 17 – 22, represents web traffic, with the y-axis providing a scaled relative to the first term and the x-axis providing the year. Each graph can be viewed as a set of index terms that provide a probabilistic framework for understanding perception and interest of comparable IAQ subjects.

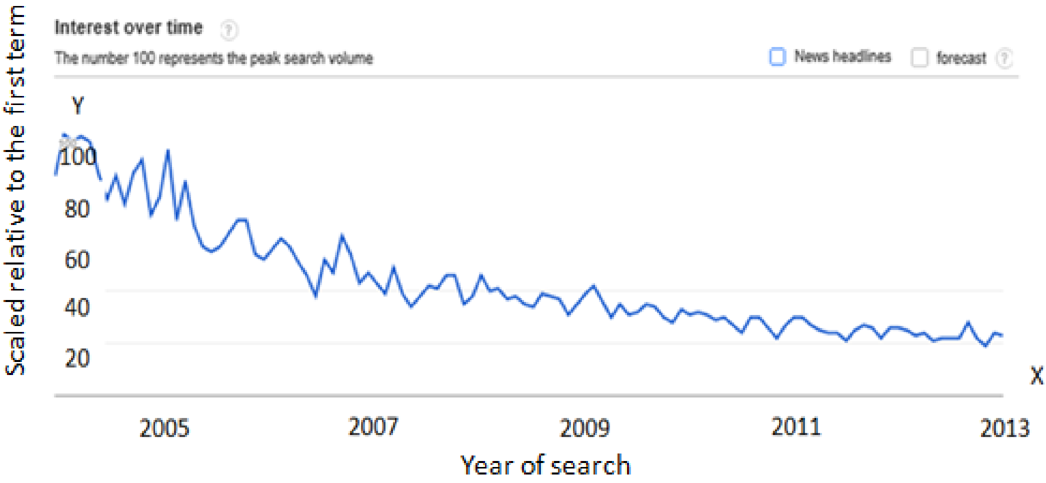

Figure 17: Google Trends of "indoor air quality" (worldwide) (28/2/13 - 09:36). Graph depicting Google trend of 'indoor air quality' searches from 2004 – 2013.

Within Figure 17, I have trended the term "Indoor Air Quality", with a peak of searches in 2004, gradually declining throughout the nine year period.

Google have indicated parallel wording used within the search terms as a comparison, revealing matching term as ‘air quality testing’ (100) which could relate to external air, ‘indoor air testing’ (95) and most revealing ‘home air quality’ (45).

The key countries, in hierarchy, were indicated as Hong Kong (100), Singapore (77), Malaysia (68), Canada (60), United States (54), Australia (26), India (19), UK (8), China (2). Although I emphasise caution regarding the data, as Google is not the primary search engine for all countries and indeed Google only recently started operating in China in 2006, despite censorship.

A filtering of countries showed univerisal decline in indoor air quality word searches since 2004., such as the US, as figure 18.

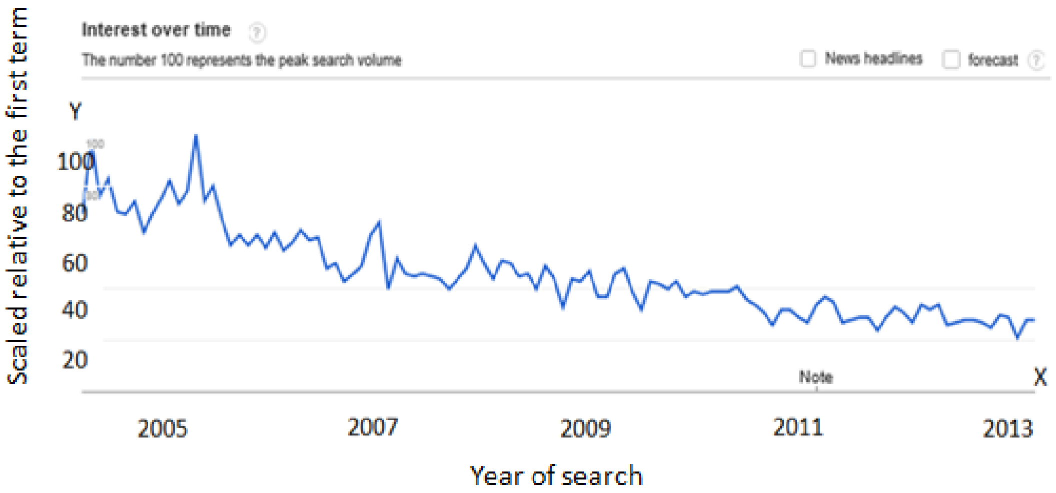

Figure 18: Google Trends of “indoor air quality” (US) (28/2/13 – 10:20). Graph depicting Google trend of indoor air quality searches from 2004 – 2013 in the US.

A search was conducted on the UK region, figure 19, with limited data for trending.

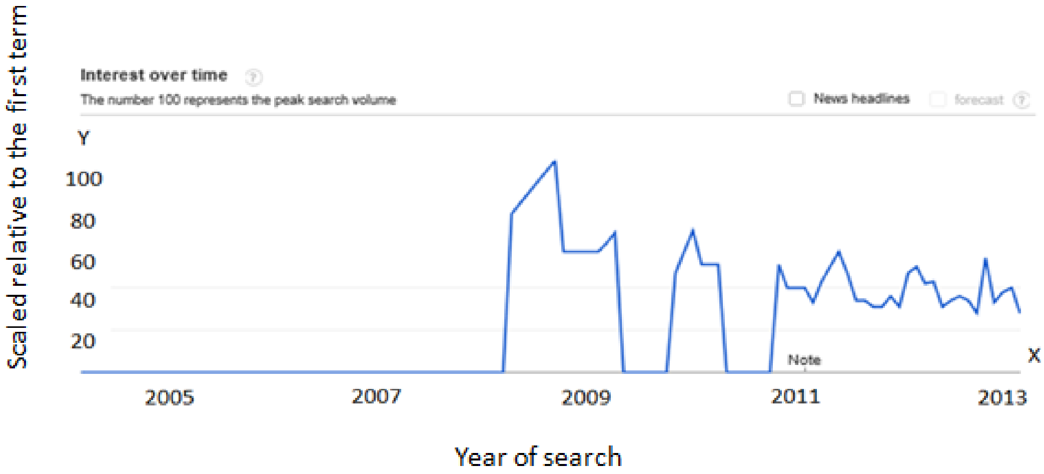

Figure 19: Google Trends of "indoor air quality" (UK) (28/2/13 – 10:35). Graph depicting Google trend of indoor air quality searches from 2004 – 2013 in the UK.

With the exception of India, who has seen a relative increase of 10, all countries have represented a decline. When comparing indoor air quality, figure 20, (blue line) with other topics (red line), there is a reduction in traffic activity. Below indoor air quality is almost invisible compared with global warming.

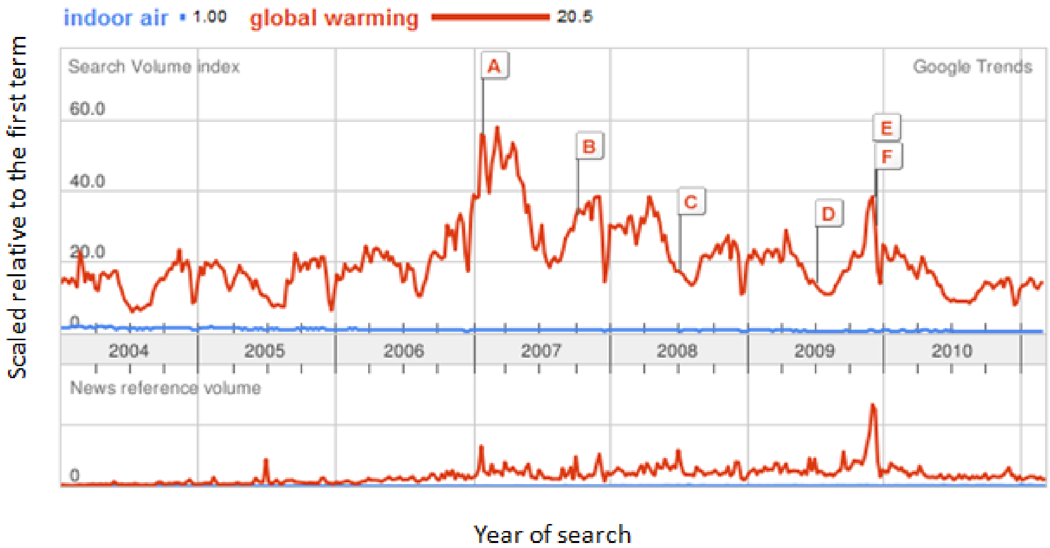

Figure 20: Google Trends of "indoor air quality" and "Global warming" (worldwide) (19/3/11 : 18.55).
Graph depicting Google trend of indoor air quality searches from 2004 – 2010 in the UK.

When indoor air quality is compared with perfumes, figure 21, we see an increased activity within perfumes, the spike representing the Christmas period, whereby purchases for presents are made.

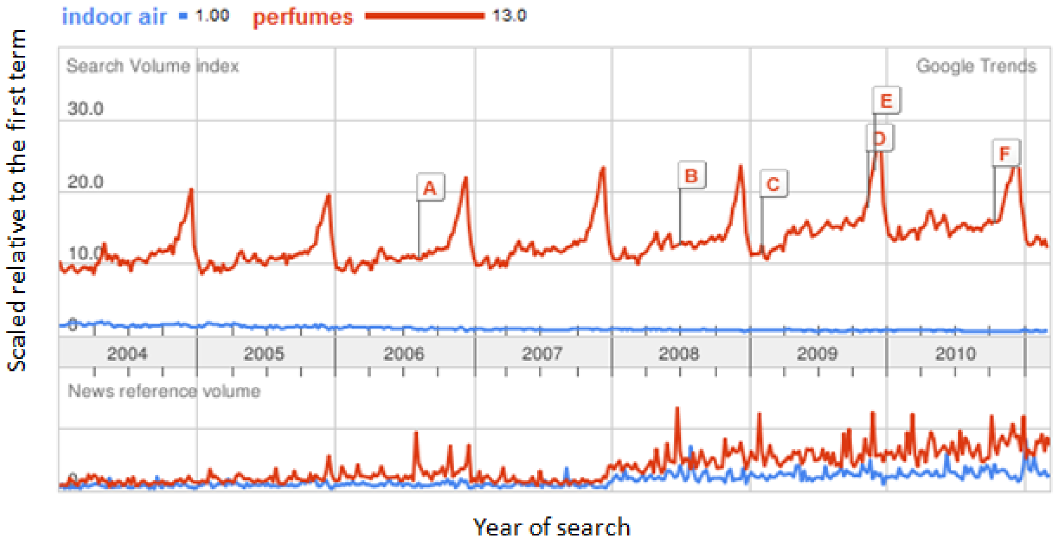

Figure 21: Google Trends of "indoor air quality" and "perfume" (worldwide) (19/3/11 : 19.10).

Graph depicting Google trend of indoor air quality searches from 2004 – 2010 in the UK.

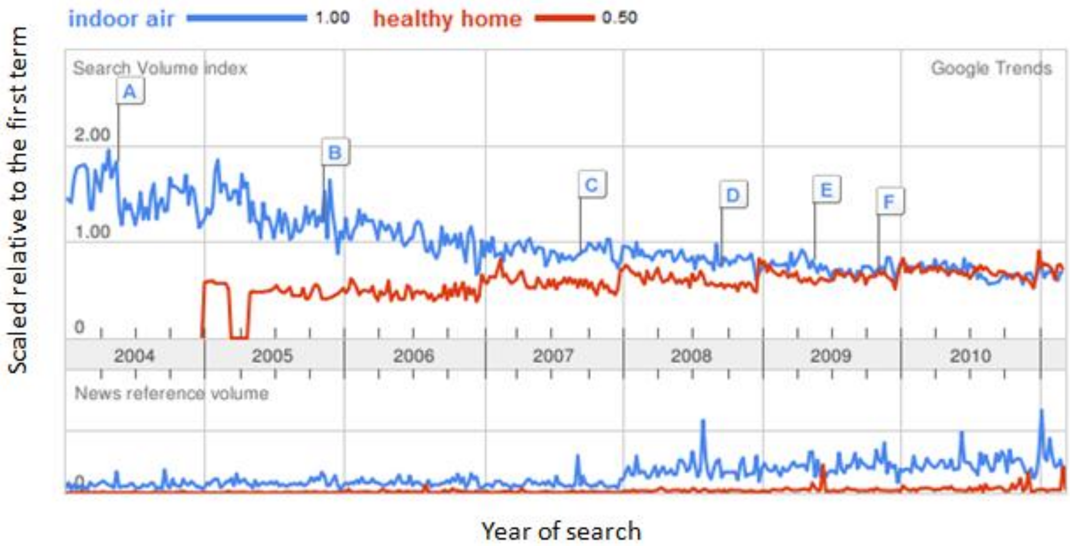

Figure 22 : Google Trends of "indoor air quality" and "healthy home" (worldwide) (19/3/11 : 19.10).

Graph depicting Google trend of indoor air quality searches from 2004 – 2010 in the UK.

An increase in individuals concern about creating a 'healthy home' figure 22, is a potential broader avenue for generating interest from the general public regarding IAQ. Although the data is from a lay resource and may contain inaccuracies and approximation data, it does indicate interest levels within subject matters and may influence strategies and language used to influence individuals regarding IAQ.

Website Design

The extensive growth of the internet has initiated the largest repository of information accessible at any time and available to a range of users. Growth and popularity of websites have taken a central role in providing information in diverse fields such as in finance, education, medicine, industry and business (Fox and Rainie, 2003). In the globalised world, users have greatly increased their demand for information and websites are being used as an important information platform. Therefore the use of the internet to provide a portal of information is an important factor in raising the agenda of IAQ, maximising audience and providing a credible resource. According to Atkinson et al., (2009, p1), 58.5% (of 3244 respondents) have searched for health related information indicating a strong and viable tool users access for information.

Freedom of such information has questioned the heterogeneity, lack of publishing control and quality of the website contents. Fox (2006) conducted a national survey reported of 1,990 adult American citizens. reporting that a quarter of the research participants do not consistently check the source and date of the health information they find online. (Fox, 2006, p4). Hanif et alk., (2009) recommend various codes of conduct or quality rating tools to assess the quality of health websites.

Therefore the methodology of designing and developing a portal is essential to ensure the quality of content and participation of users.

The majority of suggested web evaluation models and methodologies tend to focus on the user interaction regarding the design performance or the website, rather than the quality of information, many of the models are objective than subjective, quantitative rather than qualitative and do not take into account the user perception (Dhyani et al., 2002).

Bruns (2008) discusses the transformation of the internet from repository to an inactive platform where users can be receivers or active harvesters of information. Since commencing this project, the use of mobile technology has exploded, with Tim Cook, Apple's Chief Executive predicted tablets will outsell pcs (Telegraph, 2012), thereby creating a different type of user and interaction. Therefore, as the platforms for internet interaction grows, the development of social networking as a method for debating and sharing information is a valuable tool and therefore within the design stage a RSS feed, a blog and a chat facility was incorporated. CIBER (2010) conducted extensive research on the impact of social media within the research lifecycle, identifying key users and positioning of use, concluding that social media was creating an impact on scholarly research:

> '*Social media are helping to fulfil the demand for cheap, instant communication between researchers fuelled by the growth of collaborative and interdisciplinary research' (*CIBER, 2010, p23*).*

Despite the growth in social media and mobile internet platforms, academia has been criticized for failing to adapt learning environments that incorporate such technology (Lederer, 2012). Guy (2012) exploration of social media for education concludes by advising academia to embrace social media as a platform for learning. Social platforms provide a direct and immediate dialogue between author and audience, it stimulates a 'pull' of interest and can encourage self-learning; therefore I will continue to explore various platforms, such as Twitter, to continue to raise the visibility of IAQ.

Usability

Gehrke and Turban (1999) indicated slow speed was the biggest complaint following a survey of 130 e-commerce customers across 40 websites accounting for 77% of respondents (p2). Users are more likely to lose interest in a site if the download time exceeds 10 seconds (Nielson, 1996). Therefore keeping web pages loading to below 60KB (Wilson, 1998) and keeping graphics and animation to a minimum (Haine,1998). Then ability to navigate without becoming confused or lost contributes to a user-friendly service. Tadjer (1998) supports a navigation bar on each page. Hot buttons provide easy navigation and a personalised effect to the Web page. Busch (1997) recommends using simplified shapes and colours. The usability navigates towards speed, efficiency and simplicity.

Content

The quality of presentation and the usefulness of content determine attraction of users Gehrke and Turban (1999) and Nunley (1998) suggests that information content should account for 80% of the site; however caution should be applied as to the construction of the information, as Guglielmo (1998) proposed that 79% of users merely scan pages without reading the detail. Therefore key headers and signposts required to direct users efficiently to required positions within text. Gardyne (1998) provides nine recommendations: brief sentences; bulleted lists; short pages; highlighted keywords; colourful, descriptive paragraph headings; one idea per paragraph; most important point first in each paragraph; and half the word count (or less) of conventional writing.

Dalal et al., (2000, p607) reinforces this message by stating the current problems caused by design errors in complex websites are overemphasis on multimedia presentation, irregular and meaningless links, and inharmonious web pages with a lack of information prompts.

During exploring website design, I decided to use an establish web hosting company that offered templates that could be customised for the content, this also ensured achieving user-friendly design standards would take less time for me to develop. Despite the literature discussing design and performance of websites, the concept of quality evaluation is not yet a clear and unambiguous definition within the evaluation models. Adams (2010) reviewed 56 sources of academic disciplines and reported concern regarding the reliability of information, especially accessed by the lay user to user information exchange sites (social networking) platforms not regulated by traditional medical models of authority or sources of information. Adams (2010) also discusses:

> ‘*Transparency and disclosure remain important in a more general sense’* (Adams, 2010, p6)

Hajjem et al., (2005) conducted a 10 year study of tracking citations within articles and journals and found open-access articles were significantly higher than those who remain behind subscription barriers. Therefore, along with quality and usability, free access may also increase usage and transferability into future research within IAQ. Upon reflection, despite offers from commercial organisations, I have declined sponsorship and advertisement on the site, which may detract from the independence offered. The credibility of the site and the availability against the myriad of choice is crucial for user interaction, thus generating knowledge transfer within a new landscape. I also refer back to Johnson’s (2008) comments about Priestley, page 43, and his passion to share information from his cabinet of wonders.

Since commencing my DProf programme, the explosion of handheld devices to access the internet has increased. The Office of National Statistics in the UK (ONS) conduct opinions and lifestyle surveys every month and report approximately 1,000 random sample telephone interviews are conducted to provide estimate trends in the UK.

In 2012, the ONS (2013, p1) estimated that 33 million adults accessed the Internet every day, more than double the 2006 figure of 16 million, when directly comparable records began, this may be due to the use of mobile phone access. ONS (2013, p1) reported that between 2010 and 2012 access to the internet via phone more than doubled from 24% to 51% and that 32% of adults accessed the Internet using a mobile phone every day.

I am also interested to explore further the emergence of mobile learning (ML or m-learning) (Abernathy 2001), which is the next era of e-learning. Multi-device learning design is to supplement traditional methods of learning and accessing information, which stimulates an evaluation to understand the impact of such knowledge sharing and more importantly knowledge retention. I was particularly interested to understand whether such concepts contribute towards lifelong learning.

I read with interest Gu et al., (2011) research on the evaluation of mobile learning and that such a concept could be an inclusive value within the daily lives of users. This is such a powerful statement for inclusion factors whilst debating how to raise perception and interest in IAQ. Despite the report being written in 2011, the example of m-learning was presented on a Nokia E66, black and grey 2.4 inch screen with basic functions of directional (up, down, left, right) keys, a widely divergent experience using today's technology of tablets and smart phones.

The internet is changing at such a rapid pace, including the devices we use to access the internet; therefore I am conscious that by the time of publishing, this article will be out-dated by new advancement. The www.iaquk.org.uk site that I have developed will need to be constantly appraised, particularly understanding different platforms for educating users and acknowledging that a page of text may not necessary change practices or engagement.

Audience

The IAQ site is designed for two specific user groups:

- General (lay) visitors who would periodically visit the site for information relating to their personal interests, such as products used in the home, interest regarding health in the workplace;
- Expert visitors who would require a high level of information and specific regarding substances, monitoring and managing methodologies.

Such diversity provides an interesting challenge to stimulate both users.

Validity of knowledge transfer

The critical issue within indoor air science is the dissemination, adaptation, utilisation of information and the transfer from usable resources into effective indoor air quality management. Therefore it is not just the content of the resources but the interface between the various stakeholders within an organisation. Van Bree, et al., (2003) contemplates this dynamic of the Clean Air for Europe programme when discussing how to:

> '*Bridge the gap between air quality policy, stakeholders, the public, and scientific communities'*.(Van Bree, et al., 2003, p1)

Van Bree et.al (2003) concept of science, society, policy and stakeholder interacts and co-operate in generation, dissemination and evaluation of risk-based IAQ policy options and priorities. The findings of the reviews from my research were used to help implement developments for indoor air quality competencies and standards, creating transferable data. Tserng and Lin (2004) discuss six project success factors when engaging with contractors (project team commitment, contractors' competencies, risk and liability assessment, client's knowledge, end-users' needs and constraints imposed by end-users) when evaluating the success of developing knowledge management systems.

Although this project evaluated construction design and build projects, there is a parallel to be explored regarding the six success factors. Knowledge management leverages skill and awareness both within the organisation and externally to the benefit of their contractor and future development of IAQ.

Miller (1979) passionately challenges the effectiveness of technical communication which is relevant to the transfer of data within the IAQ website:

> '*A passive construction of an online environment could prevent text from relating to navigation, creating a world that makes no sense to anyone who visits it, and provides no amount of motivation for discovery. Navigation and content should work together to foster an avenue for active searching; they should support each other and drive activity toward one another. How to encourage the reader to change their roles from a passive responder to text to one that is actively engaged remains the challenge*' (Miller, 1979 p614).

Implementation

The website was published by a web hosting package, which included the purchase of the domain name - IAQUK, an online platform to design and publish the website, using pre-selected templates that could be changed and adapted, email addresses using the domain name and statistical software to monitor traffic. The ontologies structure was presented in a simply format identifying key subject matters, as illustrated within appendix 8, page 417:

- Central Homepage;
    - About us;
    - News and Events;
    - Training;
    - Membership;

- In the Home;
- Resources;
- Links;
- Contact IAQ (which included blog, RHSS and the OHS practitioner survey.

As a novice to web design, the process took 6 months to design and fill with suitable content (September 2010 – February 2011), thereafter maintaining and adding data to the site. Information gathered from my literature review was used as the significant source of data, with supplementary data from suitable sources such as the telegraph. I designed the logo, with the intention of appealing to the layer reader, with a home theme:

Figure 23: IAQUK Logo
Logo I designed for my IAQUK website

The software package also assisted to register my domain for free with key search engines (Google, Lycos, Bing, Yahoo and Ask Jeeves). No additional costs were spent for premium listings or per to click advertisements. I have discussed my findings within chapter 5 regarding traffic to site and pages with highest hits.

Screenshots from IAQUK website are illustrated within appendix 7, page 416.

The www.iaquk.org.uk website is the first dedicated, non-commercial, website in the UK. I intend to continue developing this space as a legacy from this project with the intention of providing a central platform for collation of data for future research.

4.4 Change Management

Within my project, my intention was to influence change within the field of indoor air quality, which involves engagements across a range of stakeholders. In addition, the social, economic and political agenda is critical to be considered which may present challenges to such influences. Therefore I have developed a contextualised action model to visualise the influences and expected outcomes from application of learning.

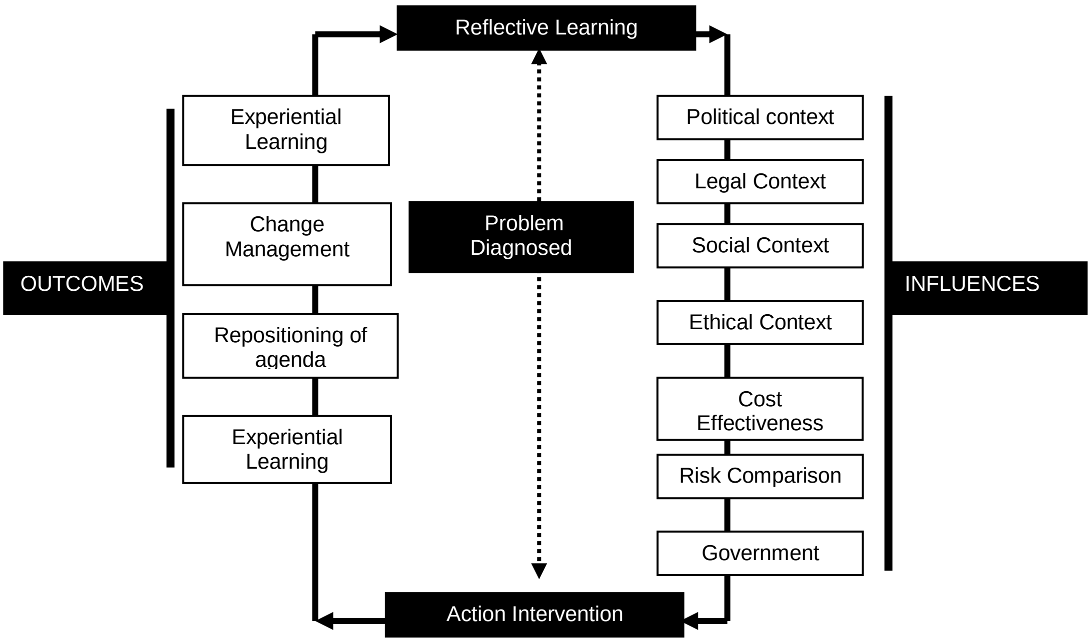

Figure 24: Contextualised Action Model
A helicopter view of project activities.

As previously explored within my literature study, a contributing failure of the lack of understanding of IAQ within the UK can be attributed by lack of ownership/direction and silo organisations within the IAQ community. The key aspect of this collaborative of stakeholders discussed in chapter 2.5 is to ensure sustainability within the indoor air quality field, which involves influencing a consensus within a common goal.

‘*Firstly, that there is a need to democratise the knowledge process -- so people normally shut out from research and information become involved in the research itself, learning how to obtain information and how to use it. And secondly, that my work has a social change emphasis -- whereby the goals of research are to engage in action that reverses inequalities, empowers the have-nots, and ultimately transforms society so decision-making becomes more transparent and democratic’* (Allen, 2001, p1).

Allen (2001) succinctly frames the engagement of individuals with the subject matter and allows those individuals to make decisions/choices on applied knowledge, thus establishing an integrated, sustainable approach. A critical area of the project is the influence in change management, in particular:

- Development of centralised indoor air quality resources;
- Establish indoor air quality OSH Practitioner’s awareness;
- Establish UK indoor air quality accredited training certificate with a national training body;
- Discussions and recommendations for further developments.

This research is founded on leading to advances in practices, therefore I reflected on Beckhard and Harris (1987) questions:

- *What needs to change?*
- *In what parts of the organisation?*
- *What types of change are required?*
- *Whose support is needed?*
- *How is commitment to be built?*
- *How is resistance to be managed?*

These questions are critical boundaries to ensure change management is addressed.

Within my project, my intention was to influence change within the field of indoor air quality. There are numerous models for strategic management change for formulating, implementing and evaluating cross-functional objectives. Many have limitations of a narrow focus or are limited by moments of popularity and perhaps may be labelled as ‘pop theories’.

Prosci’s (1998) ADKAR model for change is an effective model to examine awareness; desire, knowledge, ability and reinforcement within determine effective change management activities. The model provides dynamic dimensions to evaluate resistance to change and the various transition processes involved.

The application of change can be influenced by the dynamic environment that is subject to change due to the impact of various change triggers, such as political influence, cynicism, organisational objectives, resources, cost of change, work processes, ineffective leadership styles and motivation. Therefore a collaborative, constructionist approach to change of creating a framework for future developments, regulation and research will prevent barriers to advancement and allow contributions to centrally agreed objectives.

Resistance to change is also an essential factor to be considered within this context; failure to understand resistance will invariably hinder the process of change management. Pardo del Val and Fuentes, (2003) empirical research identified common reasons for change, citing deep routed values, capability gaps and departmental politics as the sources of resistance to change. As a conclusion Pardo del Val and Fuentes (2003) asserted training can be a good tool to surpass communication difficulties and reduce the gap between the present situation and capabilities required for the change process.

Kotter (1996) cautions a major problem when implementing change that people need to be taught not only technical skills but also social skills and attitudes needed to make the new arrangements work.

Resistance to change is a complex with various dimensions. Therefore I would suggest that resistance is not to become frustrated by, merely an opportunity to understand the drivers to embed sustainable change. The essence of change management lies in a capacity for self-learning and evolutions, rather than linear adherence to a structured, detailed plan. Therefore my approach to management change will be proposed as laying out the general path, but not the precise steps, by which an organisation intends to create value (Moore, 1995).

Lewin's (1943) force field analysis would assist in understanding the current driving forces and restraining forces to achieve effective change within IAQ, with the intention of moving from the current:

- IAQ is often represented in silo topical debate, hidden in alternative subject matter such as climate change and building design, skewed by government reports with disparate resources, an absence of ownership and direction; reinforced by the paucity of application to a real world environment and sparse evaluation of a changing society.

Into an optimum situation:

- Engaged and competent stakeholders, clear leadership and ownership, policy and guidance to drive self-regulations, cost effective modelling, engaged and competent stakeholders, clear leadership and policy), transparent labelling, effective bio-monitoring and multi-pollutant frameworks and essentially an improved indoor environment with low emission rates.

To understand Lewin's model I have listed key themes running through this project as identified by my literature review and survey findings:

Driving forces	and	**Restraining forces**
Better health	→ ←	Habitual behaviour
Effective building and energy management	→ ←	Perception of low risk
Reduced sickness	→ ←	Deficient resources
Improved productivity	→ ←	Lack of competent advice
Improved morale	→	

Lewin's theory is that driving forces act as the change agent and should outweigh the resisting forces. This can be accomplished using a weighted response.

Following a review of literature and training, the findings will establish a conclusion and recommendations to focus on developing knowledge and resources; understanding the main drivers and barriers to providing an intelligent indoor air quality society.

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4.5 Conclusions

Following the completion of the two surveys, a literature review and the application of triangulation, I identified gaps within IAQ knowledge, with the intention of implementing two transformative projects:

- Development of the first UK IAQ accredited training certificate;
- Development of the first UK's dedicated IAQ website.

Exploring pedagogies and existing IAQ training programmes, I considered motivation and the output of transformative learning was indispensable to assist with raising the agenda of IAQ. The ultimate goal of my certificate was not to provide an instructional programme that answers all questions, mere a professional learning environment, that is interactive, reflective, that incorporates real world application and provides a range of solutions, experience and knowledge; with the intention of nudging the professional community into their own transformative learning epiphanies.

Using motivational and leadership models I have been able to navigate the most challenging aspect of persuading IOSH to adopt a new training certificate that is represented within their CPD training programmes. I believe this was partially due to my desire and enthusiasm to persist during an 18 month period to achieve this objective.

Building a website portal was a new skill, which I have since used within my own working environment to develop internal health and safety intranet portals. An essential underpinning consideration was the transferability of the data and the persuasive use of the data to motivate and stimulate interest. I sought steerage with Van Bree et.al (2003) model on Clean Air for Europe, understanding the dynamics between the triple helix model. Therefore understanding my audience and motivations for accessing the site provided a structure to build my portal.

Reviewing existing website and traffic data from Google's statistical data enabled me to design the site with the user in mind. Accessibility was a guiding thought, thus ensuring free access to the site, Hajjem et al., (2005) further compounded this thought by discussing the citations of articles and journals and found open-access publications were significantly used than those who remain behind subscription barriers. Therefore, along with quality and usability, free access may also increase usage and transferability into future research within IAQ.

Despite my passion for delving into the literature of IAQ, I found this particular section of my project the most rewarding by delivering two unique projects as a legacy from my project, the first UK IAQ training certificate and the first UK IAQ website portal.

In chapter 5 I will be discussing the findings from both surveys and feedback from the training certificate and website traffic. I have also included a discussion on action research, triangulation and transformative activities.

Chapter 5 – Findings

5.1 Introduction

Chapter five provides a critical analysis of findings from the local authorities' and OHS practitioner's surveys identifying clear themes to drive the viability of IAQ. The chapter also includes feedback from the training certificate implemented and the IAQ website published. Collectively the findings are triangulated and discussions identified from the data compiled within the boundaries of my project dialogue. I have also included a section on action research to clearly illustrate the cycles conducted, as discussed in chapter 3, that have shaped my project activities. The chapter includes a conclusion with themes for further discussion and recommendations.

5.2 Local Authorities Questionnaire

In November 2010, 240 questionnaires were emailed directly to local authorities' environmental and health and safety departments within the UK; with 82 responses received, resulting in a 34% response rate. Sheehan (2001) reviewed email survey response rates during 1995/96 showing an average 46% response rate, which decreased to 31% in 1998/9, possibly due to competing with an increase of unsolicited emails to users.

Therefore the Local Authority response rate could be considered within an acceptable range. 19 of the 82 questionnaire did not provide job titles and department. This stimulates an interesting question as to why they did not wish to offer such information. 34 questionnaires were completed by the housing departments; 23 environmental health and 6 by the health and safety department.

An analysis of the exploratory data was conducted looking at raw data to decide on their important features. Weighted ratings (0-4) were applied to the answers, as per figure 26, page 199, to enable a standard means calculation to provide a quantitative figure for discussion..

Data was grouped to analyse a linear relationship. In order to provide a visual presentation excel histograms are published within appendix 5 for each question, accompanied with the raw data to enable future studies and a standard mean table is presented with each discussion. An excel linear plot is used for some questions with the intention to evaluate relationships amongst pairs of variables. A schematic of the data analysis is illustrated below.

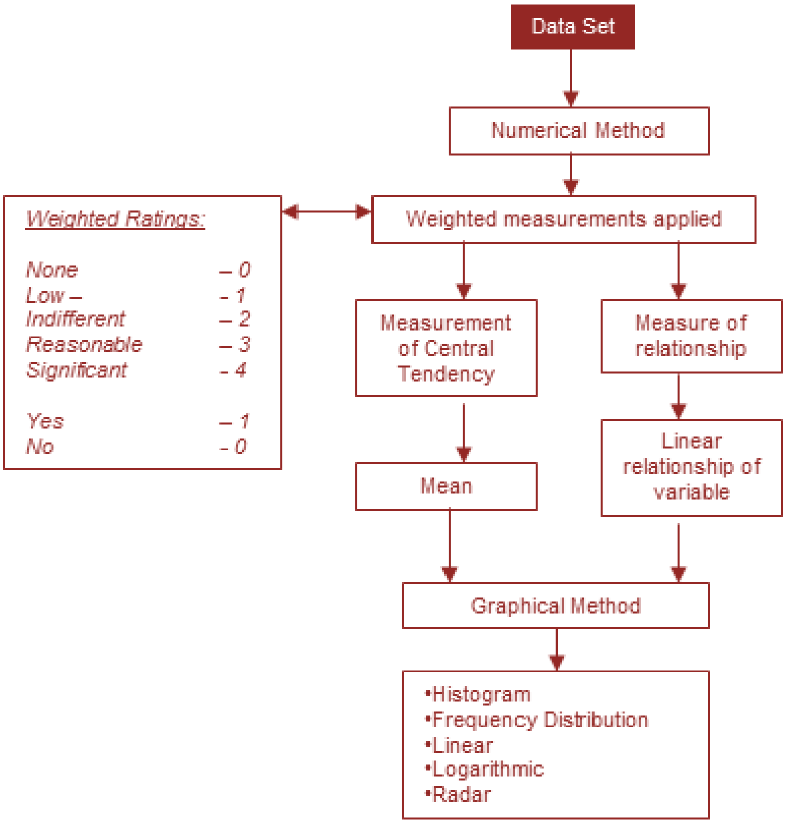

Figure 25: Schematic of the data analysis.

Methodology used to analyse data from the EHO's survey.

The full raw data is provided within appendix 5, page 402. To explore the statistical value, I explored each data set by applying a weight rating to each response and measured the central tendency, in this case the mean to understand the importance placed on the responses.

Such calculation provides a clearer response for the reader. Below is an example calculation using the raw subset data within question one of the EHO's survey.

Please rate the importance of health risk with regards to the following topics

Importance -		None	Low	Indifferent	Reasonable	Significant
Mobile phone towers	A	12	55	4	5	6
Weighted Ratings	B	0	1	2	3	4
A x B = C	C	0	55	8	15	24
Standard mean for Mobile phone towers		20.4				

Figure 26 - Example of Data Analysis for EHP survey.

Example calculation using subset data within question 1 of the EHO's survey.

By applying this calculation to each answer within the question, a comparison of answers can identify significant views from the respondent, steering the discussions within chapter 5.

Question 1: Rate the importance of health risks with regards to below topics.

Table 6 represents the central tendency of weighted responses. The subset data provided an initial understanding of how indoor air quality is perceived according to other environmental risks.

Table 6: Rate the importance of health risks.

A standard mean calculation of responses to Question 1 from the EHP survey.

Rate the importance of health risks with regards to topics.	
Standard Mean	
Mobile phone towers	20.4
Insecticides and weed killer residuals in food	19.2
Food poisoning	49
Obesity	50.4
Air pollution from cars	63.2
Air pollutions from factories	61.4
Indoor air quality within a sealed HVAC building	28.8
Indoor air quality within a naturally ventilated building	26.6
Stress	48.6
Cigarette smoking	65
Drinking alcohol	55.8
Chemicals/additives in food/drinks	44.2
Chemicals in beauty products	20.6

Table 6 reveals how indoor air quality is considered moderate (26.6 naturally ventilated / 28.8 for mechanical) compared with external air from factories (61.4) and cars (63.2). Cigarette smoke was considered the most significant (65). The weighting response of the EHO's views towards smoking is comparable with epidemiology studies, Cancer Research UK (2009) claim that 3% of lung cancer cases in the UK are caused by air pollution compared with smoking that causes up to 90%. This means that smoking causes nearly 30 times more lung cancers than air pollution does. Although smoking has been addressed within public spaces, Cancer Research UK (2009) indicates that 40% of children are still exposed to second-hand smoke. This suggests that although the Government have legislated against public spaces, they have had limited impact on society's personal actions and behaviours. The Government spend for their Smokefree campaign in 2006 is attributed at £43 million (Telegraph, 2009). Many of the publications regarding the effects of the Smokefree initiatives have reported on the short term quit rate using access responses to smoking cessation packs provided by the Government. In particular Hackshaw, McEwen, West and Bauld (2010) reported that 8.6% smokers in 2007 and 5.7% in 2008 attempted to quit, although no figures regarding long term attempts. Bauld (2011) reported in March that there was:

> '*no evidence of any obvious effect of smokefree legislation on the hospitality industry in England'* Bauld (2011, p1).

This creates an interesting perception, that although we know the dangers of smoking and that the government has invested in this area to reduce smoking activities, people still choose to smoke. Thus presenting a hazard to people does not necessary make them change a habit, thus stimulating the debate that change is dynamic and promoting IAQ needs to be more sophisticated that just discussing the hazards and health concerns.

Alcohol at 55.8 was a less perceived risk compared to smoking within the survey. Within a 2008 report compiled by KPMG and the Home Office, they reported that alcohol abuse costs the equivalent of £415 a year to society for every man, woman and child, with around a quarter of the population drinking to harmful levels and an estimated cost to the NHS of £2.7 billion a year (KPMG, 2008). Not all costs are directly attributed to alcohol and the report discusses events such as accidents and violence are recorded separately. Since 2008, no further costs have been published by the NHS, however they have claimed that admission to hospitals have increased from 2008 (945,000 in England) to 2010 (1,057,000 in England) (NHS, 2012). Home drinking has increased (Institute of Alcohol Studies, 2010) particularly in wine, 83% of all wine was purchased at off-licence outlets, compared with a significant decrease (21%) in beer consumption (British Beer and Pub Association, 2007). Measham (2008) discussed an increase of 'extreme drinking' from the 1990s in young people's alcohol consumption; although this has been challenged by Griffin et al., (2009) suggesting that is the young people's public displays of extreme drinking' which help to constitute this view. Griffin et al.,(2009) refer to the equally excessive (but altogether more private) alcohol consumption of the middle-aged, middle classes which could be viewed as more civilized and moderate.

Other health concerns, such as obesity (50.4) are seen as an increasing risk, with obesity linked conditions costing the NHS approximately £4 billion a year (NHS, 2011). The Information Centre for the NHS discuss the rise in obesity in children (1 in 10 pupils aged 4-5 years / 1 in 5 pupils aged 10-11 years) and the concern that in 2025 47% of men and 36% of women will be obese. (NHS, 2011). Chemicals in food (44.2) ranked higher than air quality, which may be due to the organic movement. Although interestingly insecticides and weed killer residuals in food was a comparison low perception (19.2). Willer and Kilcher (2011) discussed the growing market for organic food, declaring agricultural land used for organic farming has expanded by 20% annually in Europe, which indicates a consumer demand for an organic choice. Fitzpatrick in 2002 estimated a $20 billion market globally.

There are varied reasons why consumers make such a selection, including ethical principles, such as ecological sustainability and care for animal welfare (Willer and Kilcher 2011), supports local producers (Fotopoulos and Krystallis, 2002), the perceived healthiness of such products, including the views of genetically modified products (Guido 2009). The most familiar association with organic is the chemical-free practices (Harper and Makatouni, 2002, Hill and Lynchehaun, 2002). Such consumers groups often related a lifestyle that may also include environmentalist, alternative medicines, natural cleaning products, vegetarianism (Cicia et al., 2002).

Makatouni (2002) describes such consumers as individuals with an internal locus of control who are interested in preventative health actions. An exploration of such consumer views on indoor air quality would provide value as to how to stimulate sustainable discussion on reducing impact of IAQ on occupiers, particularly around choices of products, perfumes and furnishings chosen for their home.

Air pollution (from cars 63.2 and from factories 61.4) are ranked high, which correlates with the type of work and training received for Environmental Health Practitioners. The EC report (2004, p9) evaluating of attitudes of citizens towards the environment by surveying 24,798 people from 15 member EC countries discussing similar risk perceptions, with 45% of citizens were worried about air pollution compared to 35% concern regarding chemicals within everyday products. In 2010 only 35% of citizens were worried about the air pollution, with 35% worried about chemicals, demonstrating a reduction. COMEAP (2011) reviewed the public's perception of air pollution, particularly assessing the actual and perceived link between health and air pollution.

They concluded that by identifying a lack of accessible and understandable information lead to a negative perception of air quality. This was particularly evident in their public reporting of air quality whereby the lay person reading the reports was unable to interpret the data.

Therefore COMEAP made suggestions to redesign their reporting for intended audience, which included using visual cues and colours, such as the traffic light colour coding of air quality results (red, yellow, green) to assist with transferring of data to the public.

Throughout this section, I have discussed perception of risk in terms of extensiveness or frequency of risk to the public and associated costs.

However risk perception is shaped by many factors.

> *'The probabilities and consequences of adverse events are assumed to be produced by physical and natural processes in ways that can be objectively quantified by risk assessment. Much social science analysis rejects this notion, arguing instead that risk is inherently subjective'*. (Slovic, 2011, p3)

Dr. Paul Slovic has written extensively about risk perception and human decision making when analysing risk; and my brief acknowledgement of his work within this section would not provide justification to his contribution on this matter; however I did find his suggestion that risk perception can be shaped by many factors, such as the media, and not necessary the risk itself Slovic (1987). Within his 1987 paper he illustrated a scaled factor space figure of perceived dread of a risk, compared with the knowledge of the risk. From his table we can see people are generally more accepting of a risk if the hazards are known, this included smoking and drinking.   Compared with unknown risk of radiation, polychlorinated biphenyl (PCB), nuclear power and pesticides are perceived as more risky.   Exploring attitudes to IAQ and risk ratings will assist with changing culture and behaviour.

Question 2: Please compare the importance of indoor air quality with regards to health impact with other environmental considerations.

Within table 7 below, the perception is normalised when compared to similar environmental risks; asbestos being the most significant, but limited variance between the topics. This might be due to environmental enforcement agencies viewing environmental topics as a holistic cycle which impacts on each element. Compared with a similar survey completed by the Health Canada Organisation (2002), air quality was seen as the most important factor affecting Canadians with a 28% response, followed by 12% believing water quality.

Table 7: Compare the importance of indoor air quality with regards to health impact with other environmental considerations.

A standard mean calculation of responses to Question 2 from the EHP survey.

Compare the importance of indoor air quality with regards to health impact with other environmental considerations.	
Standard Mean	
Indoor Air Quality	50.8
Outdoor Air Quality	54.2
Noise (nuisance)	57.6
Water pollution	49
Asbestos	62.6
Land pollution	49.6

Interestingly many of the comments regarding the Canadian survey followed the visible aspects of air quality:

- *I now am very, very aware that on really smoggy days I do not go down to the lake front, I don't take the kids outside. It has definitely affected our lifestyle;*
- *"I mean, we're getting those smog alerts more and more often;*
- *"If you look back towards Vancouver, you'll see a yellow haze running straight as far as the eye can see. And that's something that's happened over the last 15 years. It's definitely getting noticeable.*

  Health Canada Organisation, 2002, p22).

These comments draw a parallel to Moschandreas and Relwani (1992) report on how the visual stimulus to an odour source can increase unacceptability of activity e.g. the smoker enhances the intensity of tobacco smoke, the yellow haze associates a risk of air pollution. The impact a hazard creates to our senses provokes our response as to acceptable or unacceptable, which I have acknowledged within early chapters regarding the pleasantness of a smell and the visual stimulus. Even within the low risk perception of water pollution (49.0) they can also be subject to perception, particularly with odour or taste detection. Jardine et al., (1999) suggest that unless water utility companies provide credible evidence for the cause of odours/taste, it can create an indefensible position with the general public and their perception of risk. Risk perception from the general public cannot be dismissed as irrational or irrelevant and the need for clear, easy to interpret risk communication is clear.

Question 3: Please rate the impact of proactive IAQ.

Improving building efficiency seems to represent a slight priority over reducing health care costs. This would be interesting to explore whether the respondents feel there is a direct linear relationship with cost efficiency or whether the respondents are from a community that inheritably are more environmentally aware.

These factors are all interrelated, however demonstrating a linear relationship between comfort and productivity is challenging. A cost effectiveness model for demonstrating the business case of proactive IAQ would be valuable to raising the agenda, appendix 2. Interestingly the respondents have perceived the provided answers within question 3, table 8, as separate matters and have not formed a combined interconnected understanding that improving the building environment will subsequently improve the occupant's health and comfort. Such judgement may be due to the silo disciplines, ownership and methodology IAQ information is taught and presented within this field.

Table 8: Rate the impact of proactive IAQ.
A standard mean calculation of responses to Question 3 from the EHP survey.

Rate the impact of proactive IAQ	
Standard Mean	
Reducing health care costs of occupants	50.2
Improving building performance/energy efficiency	53
Improving comfort of occupants	34.8
Improving productivity of occupants	28.8

Question 4: Which indoor air contaminants appear to present the greatest health risks?

Reviewing the pollution element within the environmental health degree programmes, as discussed later in this chapter, the responses within Table 9, demonstrates an understanding of key contaminants in the air taught within the syllabus as accredited by the Chartered Institute of Environmental Health (CIEH). The topics contained within table 9 represent the Government key aspects of air quality, as presented by the WHO air quality guidelines of selected pollutants (2010).

Therefore the dual approach of influencing both Government and accredited training would contribute towards raising the agenda. These topics are not weighted by WHO as to the level of chronic and acute health risks. The HSE's EH40 document (HSE, 2005a) publish standards for diverse sets of chemicals indicating time weighted exposure limits, which can be used as a weighted risk assessment. The impact of low risk contaminants over a longer duration poses a question whether low risk should be considered negligible when there is a risk of a greater exposure.

Table 9: Which indoor air contaminants appear to present the greatest health risks?
A standard mean calculation of responses to Question 4 from the EHP survey.

Which indoor air contaminants appear to present the greatest health risks?	
Standard Mean	
Mould/Dampness	54.6
Carbon Dioxide	36.6
Volatile Organic Compounds (VOCs)	57.8
Benzene	62.4
Carbon Monoxide	64.8
Dust	52
Biological matters	53.6
Odours/Perfumes	17
Low/High temperature	19.4
Low/High Humidity	15.2

The lack of understanding regarding new topics of concern, such as perfumes and odours demonstrates the need to influence educational establishments to update their training syllabus with additional aspects of air quality. Curiously respondents have failed to recognise the similarity of volatile organic compounds and perfumes/odours. Is this due to the acceptability of the smell from perfumes?

Fischhoff et al., (1981) commented that risks that are perceived as familiar, voluntary, natural or under an individual's control are more accepted than risks perceived to be unfamiliar, involuntary or exotic, the more acceptable the smell, the more acceptable the environment. In a commercial sense this has been exploited by one air freshening company who broadcasted a television advert whereby individuals were blindfolded and taken into a perceived smelly environment (in this case a wrestling team's changing room) and asked to smell various sporting garments, the individuals verbalised floral, citrus smells. As the blindfold was removed they were shown to be surprise and alarmed at the environment and the items they had smelt.

Odours can influence the assessment of indoor and outdoor air quality (Cain, 1987). Risk perception and the correlated personal perception of health risks of an individual is an important factor to considered within the indoor air quality discussion, although caution should be applied to skewing overreaction to risk whereby public demands for remediation even when experts judge the risk from exposure to be minimal or non-existent (Neutra et al*.,* 1991).

Aside from the olfactory stimulus, real time visualisation of indoor air quality using measurement tools can create an consciousness to improve indoor air quality. Considering the previous discussions around accessibility of data, I read with interest a paper discussing a domestic sensor connected to an iPod which displays a graphical image of the air quality, in this case the measurement of particles (Kim and Paulos, 2009).

The paper discussed a positive change of behaviour in the occupier to reduce contaminants in the air. Although I praise the attempt to empower occupiers of homes, the research is limited with only discussions of particulates and a questionable correlation between the contaminants discussed and the measurements taken, as indicated by the dialogue within the paper:

- *'A washing machine and a drier are over there (close to where inAir is located). I noticed air quality got poor when I run those. That was something I have never thought. I guess the cleaning detergent is the source of poorer air quality? (Participant E)'.*
- *'I noticed the air quality graph surges up around 6PM every night. After wondering why for days, I realized that 6PM is when my neighbor upstairs comes back from work with 3 kids. Kids keep running across our ceiling, well, their floor. Now I guess it is not only about the noise issue any more. (Participant B)'.*

  *(*Kim and Paulos, 2009, p3*).*

There is a risk that occupiers may not take samples in the correct locations and not understand the cause of contaminants. The paper is subject to much criticism, but the application of a visual stimulus is interesting.

Question 5: Rate the impact poor indoor air quality may have on the following conditions.

Question 5 provided a comparison with existing research on the occupants, as detailed within table 10 below, there was an acknowledgement of certain respiratory conditions with 316 standard mean for significant asthma attacks. Blood pressure has also been considered as important factor, although there is no evidence to suggest IAQ effects blood pressure.

Burge et al., (1987) conducted a nationwide survey of 4,373 office workers at 47 office sites concluding lethargy accounted for 57%, headaches 43%, stuffy nose 47% and itchy eyes 27%. The differences between Burge et al., (1987) and my survey are compounded by many factors, in particular the participant's quality of the indoor environment.

Table 10: Rate the impact poor indoor air quality may have on the following conditions.

A standard mean calculation of responses to Question 5 from the EHP survey.

Rate the impact poor indoor air quality may have on the following conditions.	
Standard Mean	
Asthma attack	64.4
Dryness/Irritation to skin	47.2
Dermatitis	46
Dryness/Irritation to eyes	45.4
Irritated nose/sinus	46.6
Tiredness	43
Stress	44.8
Anxiety	28.4
Depression	30.6
Headaches	40.8
Migraines	39
Raised blood pressure	45.2

Within the US, the Building Assessment Survey and Evaluation (BASE) study was conducted over a five-year period from 1994-1998 (US EPA, 1994), to identify components of indoor air quality and occupant perceptions. This study provided a closer examination of relationships of symptoms and building characteristics, providing statistics to allow for further discussions on building design, construction, operation and maintenance.

Occupants' perceptions of health and comfort were assessed by a self-administered questionnaire every 6 weeks in four office buildings over a 1 year period to collect information on office workers' perceptions of health and comfort. Eye irritation, nonspecific, and upper respiratory symptoms had, on average, more than 10% overall prevalence on the workers**.** There is no doubt that poor indoor air quality can lead to eye, skin, throat and nose irritation, tiredness and headaches (Skov et al., 1987), exacerbation of asthma, chronic OPD and cardiovascular disease (Jaakola and Jakkola, 2007). Indoor environments have also been linked to psychological factors such as stress (Bluyssen et al., 2011). However cognitive function such as anxiety, depression and stress were perceived as mixed contributing causes by the EHPs (44, 28.4 and 30.6), which may be due to latent symptoms. Traditionally when body mapping health impacts of hazards is conducted, cognitive conditions are rarely debated. The EH40 document (HSE, 2005a) and associated manufacturers datasheets of hazardous substances fails to discuss cognitive impact.

> '*Although physiological effects of hazardous materials exposures have been reported in various studies, psychological effects are unclear*.' (Kovalchick et al., 2002, p341).

Job stress/dissatisfaction has been consistently associated with poor indoor air quality in many epidemiologic studies (Eriksson et al., 1996; Hedge et al., 1996).

According to Cox and Ferguson (2004) mental strain and work-related stress seem to serve as a modifying factor between environmental factors and symptoms by increasing the vulnerability of the individual to environmental exposure. There is extensive research correlating the relationship with increased levels of carbon dioxide and anxiety, whether induced for drug trials (Poma et al., 2005), stimulated by indoor air (Seppanen et al., 1999) or caused by chronic obstructive pulmonary disease (Brenes, 2003). Chemical exposure has also been explored as discussed within previous chapters which poses a question whether mental health conditions are cognitive that then impact physiological changes or perhaps the reverse could be considered.

End-tidal and exhaled gas reading could be used to indicate susceptibility to conditions or used as a contributory factor during diagnoses. Further studies would be required to explore this relationship to demonstrate a cost effectiveness model for managing indoor air quality, particularly when considering the £105 billion annual costs of managing mental health in England (Centre for Mental Health, 2010).

This is an area I am intending to explore following my DProf. The survey has demonstrated a correlation between understanding of IAQ and potential symptoms.

Question 6: Rate the importance of the following causes of poor indoor air quality (IAQ).

Inadequate ventilation is the most significant response, which is a shared view since the historical concept of indoor air quality. Wolkoff (2005) confirms that a major cause of indoor air quality appeared to be inadequate ventilation; less important appeared to be outdoor and microbiological sources. Localized activities and products inside a building are seen as a low contributor of poor indoor air quality.

Within table 11, I was surprised by the low response to temperature; as a practitioner temperature is usually the most vocalized concern by occupants. Limited respondents understood the psychological impact, such as an inability to control the temperature or open a window (Karjalainen and Koistinen, 2007).

The placebo effect is well documented in medical literature; the same influences can also transfer across to a broad application; such as occupants feeling more satisfied with the temperature when they are able to control a thermostat, regardless of whether the thermostat is connected to the HVAC or not.

Table 11: Rate the importance of the following causes of poor indoor air quality (IAQ).
A standard mean calculation of responses to Question 6 from the EHP survey.

Rate the importance of the following causes of poor indoor air quality (IAQ)	
Standard Mean	
Inadequate ventilation	63.8
Contamination from outside the building (petrol fumes etc)	59.2
Contamination from internal building fabric/finishes (paint)	24.6
Too hot/cold	20.4
Too dry/humid	22.2
Artificial perfumes/nuisance odours	16.2
Inability to control temp/vent locally (due to HVAC)	14.6

In March 2003, the US Air-Conditioning, Heating & Refrigeration News website conducted an informal survey on its web site, asking - Have you installed dummy thermostats? Out of 70 total responses, 51 said yes, they had; only 19 said no. The former News editor Tom Mahoney claimed thermal comfort is 90% mental and 10% physical (Thomasnet, 2003).

The placebo effect is not exclusive to the medical profession and indeed within my own work experience I have witness a similar tacit by site engineers to reduce IAQ complaints associated with temperature.

Question 7: Please indicate your key reasons for indoor air quality monitoring.

The role of the local authorities in influencing IAQ in their main interaction is reactive, as demonstrated in table 12 below, which is a growing trend within enforcement bodies. Grigonis-Deane (2008) reinforces this view that the role is primarily:

> '*Responses to complaints rather than routine practice. Their role was described as being more reactive than proactive, due to the high workload and limited resources'* (Grigonis-Deane 2008, p78).

In a time where enforcement inspectors are being reduced and we look towards a self-regulation society, the role of an inspector is changing. Reynolds and Wills (2012) explored a similar concept with the perspectives of Environmental Health Practitioners (EHP) and the gap between the contemporary EHP role as an enforcer compared with the desires of EHPs to be holistic and contributing to proactive health goals.

Table 12: The key reasons for indoor air quality monitoring.

A standard mean calculation of responses to Question 7 from the EHP survey.

The key reasons for indoor air quality monitoring	
Standard Mean	
Due to complaint	38.5
Due to sickness/ill health	36.5
Proactive schedule monitoring	0.5
Due to needs of a project/build	0

I have discussed further within chapter 6, a self-regulation society; Williamson and Lynch-Wood (1988) apply caution to such an approach:

> *'Although cultural changes and modernisation are important goals, there is now evidence that regulation is the most effective mechanism for changing environmental behaviour... environmental regulation leads to better environmental procedures and practices*' (Williamson and Lynch-Wood 1988, p326).

Question 8: Please indicate your key reasons for outdoor air quality monitoring.

Question 8 provides a similar response to indoor air monitoring, as per table 13 below, with an insignificant increase of proactive monitoring regime to external air. Grigonis-Deane (2008) discuss the organisational constraints of the Environmental Health Practitioners and the unpredicted nature of their work due to:

> *'Having to respond to complaints or handling crisis that are unscheduled'* (Grigonis-Deane, 2008, p57).

Table 13: Key reasons for outdoor air quality monitoring.

A standard mean calculation of responses to Question 8 from the EHP survey.

Key reasons for outdoor air quality monitoring	
Standard Mean	
Due to complaint	39.5
Due to sickness/ill health	0
Proactive schedule monitoring	1
Due to needs of a project/build	0

With the reduction in local government budgets the impact of reactive management will become further concentrated, which suggests future objectives are directed by society requirements, rather than proactive measures, including the concept of creating environmental citizens taking responsibility for environment behaviours as we progress into self-regulation of society (Bell, 2004).

Question 9: Which % of sources generates complaints regarding indoor air quality (IAQ)?

Table 14 figures below provided an interesting indication with regards to key stakeholders, as most IAQ modelling has been written and delivered within schools (OPDM, 2006). This questions whether there is sufficient knowledge within schools to be managing or rather we have targeted silo populations within previous studies. IAQ toolkits have been provided for educational establishments, which may suggest evaluating a suitable medium for commercial and housing sectors.

Table 14: % of sources generates complaints regarding indoor air quality.

A standard mean calculation of responses to Question 9 from the EHP survey.

% of sources generates complaints regarding indoor air quality	
Standard Mean	
Educational Facilities (Schools, FE, HE)	4.5
Housing - Private	40.5
Housing - Social	34.5
Commercial (please indicate types below)	39.5

Question 10: Which of the following indoor air contaminants do you receive the greatest complaints?

The greatest complaints are temperature and odours/perfume. These topics can be subjective, but they also interact with our senses. Interestingly when this data is compared to Question 4 regarding which contaminants are the greatest risk, the opposite is true. This creates a perception regarding perceived high risk based on severity rather than likelihood or indeed long term exposure.

Table 15: Which of the following indoor air contaminants do you receive the greatest complaints?

A standard mean calculation of responses to Question 10 from the EHP survey.

Which of the following indoor air contaminants do you receive the greatest complaints?	
Standard Mean	
Mould/Dampness	27.4
Carbon Dioxide	17.8
Volatile Organic Compounds (VOCs)	19
Benzene	12.6
Carbon Monoxide	16.6
Dust	29.6
Biological matters	16.6
Odours/Perfumes	42.8
Low/High temperature	43.4
Low/High Humidity	37

A view expressed by the Centre for Public Health (2009), therefore suggesting perception and communication have to be incorporated into risk management by adopting a holistic approach based on understanding the needs of the occupants. Figure 27 provides a comparison of responses from question 4 and question 10:

- Question 4: Which indoor air contaminants appear to present the greatest health risks?
- Question 10: Which of the following indoor air contaminants do you receive the greatest complaints?

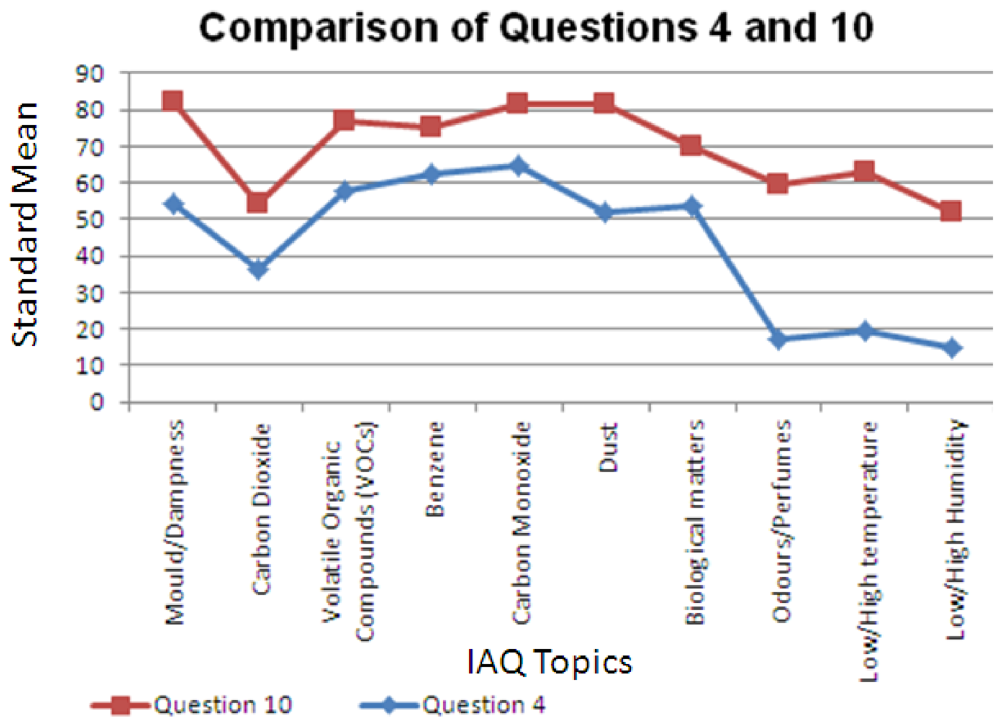

Figure 27: Comparison of Question 4 and Question 10

A comparison from the EHO's survey of risk perception and society's complaints

The comparison illustration provides an understanding regarding what is viewed as important to the general public/commercial businesses complaining about IAQ problems and what the EHPs consider a risk. Generally the comparison shows a similar relationship of perception, until the sections odour/perfume, low/high temperature and low/high humidity.

Despite the EHPs viewing these issues as low risk, society have indicated their importance and as discussed previously perception can impact satisfaction and productivity and have value within this sphere. It also reinforces my views that perfumes and scents can be a driver to engage with society regarding IAQ.

Question 11: Please indicate whether you have the following resources within your organisation?

Figures within table 16 demonstrated a significantly higher rate in identifying an individual for the public to report concerns to, although a low rate for a dedicated person or team.

Table 16: Access to IAQ Resources within organisation?

A standard mean calculation of responses to Question 11 from the EHP survey.

Access to IAQ Resources within organisation	
Standard Mean	
Dedicated IAQ Officer(s)	3.5
Contact details for the public to raise concerns	39
IAQ Policy	1.5
Information about IAQ provided on your website	2

Whilst obtaining a list of individual names to send the questionnaire to during the project activities, I used the authorities' website as the first reference point to identify a suitable contact. Apart from 3 authorities there were no dedicated IAQ contacts. During the project activities I contacted many authorities by phone to source a suitable contact and found frustration I was passed to many departments, from planning to housing and environmental health.

This was further demonstrated by the lack of IAQ policy and information on their respective websites containing IAQ information. For the remaining contacts IAQ was part of the general provisions of a Local Authority Environmental Health team. Whilst discussing with the authorities regarding the responsibility of IAQ, 7 authorities described the topic as managing '*nuisance complaints'* which diminishes the significance of IAQ.

The absence of contacts reduces the ability of localised policy, visibility, accountability and engagement with societal risks.

Question 12: Please indicate the value you place on educating the following population about improving indoor air quality (IAQ).

The data within table 17 provides a clear understanding about resolving indoor air quality at the source, via design and maintenance activities. Further analysis showed the perception regarding the role of building designers and architects with a 236 standard mean as significant, with building maintenance as 162 standard mean for reasonable.

The respondents indicated indifference to the need to teach OHS practitioners and enforcers. This is an interesting area, do enforcers feel they already have this knowledge, or is this demonstrating accountability on the part of the building design competencies? Is there a lack of knowledge associated with activities inside the building, about furnishings and perfume? Although this was acknowledged as a source of complaint with ventilation being a key issue.

Table 17: Value placed on educating the following population about improving indoor air quality.
A standard mean calculation of responses to Question 12 from the EHP survey.

Value placed on educating the following population about improving indoor air quality	
Standard Mean	
Building Designers/Architects	61
Building Maintenance/Engineers/HVAC	52
Environmental Health Practitioners	39.4
Health, Safety, Environmental Practitioners	37.4
Housing Officers	35.6
General Public	32.8

Question 13: Please indicate the value you place on the following resources to assist with managing indoor air quality (IAQ).

To understand the value placed on most preferred method for transferring knowledge into a practical setting, I proposed a variety of methods that have a similar correlation with health and safety methods. The response was very positive, within table 18; clear standards to measure against provided the strongest indicator. IAQ toolkits for housing were seen as the least value.

Table 18: Standard mean of IAQ value.

A standard mean calculation of responses to Question 13 from the EHP survey.

Standard mean of IAQ value	
Standard Mean	
Free information website for public and local authorities (similar to HSE)	292
IAQ toolkits for commercial businesses	300
IAQ toolkit for housing (private and social)	228
IAQ investigation kits for local authorities to identify route causes	308
Clear standards to measure against	324
Improvement in education (degree programmes)	312
Independent organisation championing IAQ matters	316

The data within table 18 was also explored to understand how important the resources may assist with managing IAQ, and a staggering 297 standard mean felt the resources were significant, as indicated in table 19 below.

Table 19: Standard mean of IAQ value significance

A standard mean calculation of responses to Question 13 from the EHP survey

Standard mean of IAQ value significance				
None	Low	Indifferent	Reasonable	Significant
0	0.571	4.857	13.714	297.142

Therefore despite IAQ not seen by EHPs as the most important risk factors, as explored within question 1, the value that is placed on accessing information and resources indicates an interest to understand further.

Question 14: What value would you place on delivering IAQ within an education programme?

To ensure education is delivered through a control group, I explored the two key areas of a degree programme and continuous personal development (CPD) as table 20.

Table 20: Standard mean of educational programme value.

A standard mean calculation of responses to Question 14 from the EHP survey.

Standard mean of educational programme value	
Standard Mean	
Via continuous professional development (CPD) courses	51.8
HE (incorporated into existing degree programmes)	53.6

The respondents demonstrated no preference; however when the data was explored to understand how important an education programme might be, the statistic showed a staggering 223 standard mean as significant, with an equally noteworthy 69 standard mean as reasonable, table 21.

Table 21: Standard mean of educational programme value significance.

A standard mean calculation of responses to Question 13 from the EHP survey

Standard mean of educational programme value significance				
None	Low	Indifferent	Reasonable	Significant
0	1.114	3.371	69.342	223.428

There is no substantial data reviewing the authorities or general public perception to IAQ. Academic papers focus on specific indoor air quality problems and survey occupants on their comfort/health levels. There is a gap within research to understanding current level of knowledge, motivation and engagement with IAQ if we are going to raise the awareness and knowledge and encourage further development into policy, education and control strategies and inspire further research of body burden and multi-pollutant research.

Within the EC (2004) a survey of 24,786 people across 15 member EU states was conducted classifying attitudes of European citizens. No demographic data was provided by this survey. Collectively the respondent agreed, 94% of those surveyed that:

> '*The state of the environment influences the quality of life'* (EC, 2004, p29).

This has reduced to 85% in 2011 (EC 2011) report, which was indicated as due to the global economic situation. When 2004 survey is filtered, the UK only presented 68% agreement. Although this research discusses environmental concerns, the parallels between people's perception of the environment, their health and the difficulties of managing complex issues can be explored.

As an example, the collective European respondents (46%) indicated that the most effective method for solving environmental problems was via EU Regulations and heavy fines, thus embracing the polluter pays attitude.

> ‘*Stricter regulations, with heavy fines for offenders” are perceived as the most effective solution in dealing with environmental issues by 66% of citizens in Greece. This rate is 20 percentage points above the EU25 average. On the contrary, citizens in Estonia, Latvia and the United Kingdom do not seem as convinced about the effectiveness of such a solution’*. (EC, 2004, p37)

Contrastly the UK have represented a different view, favouring enforcement of existing legislation and raising awareness, as opposed to new legislation and taxes, as shown in figure 28 below.

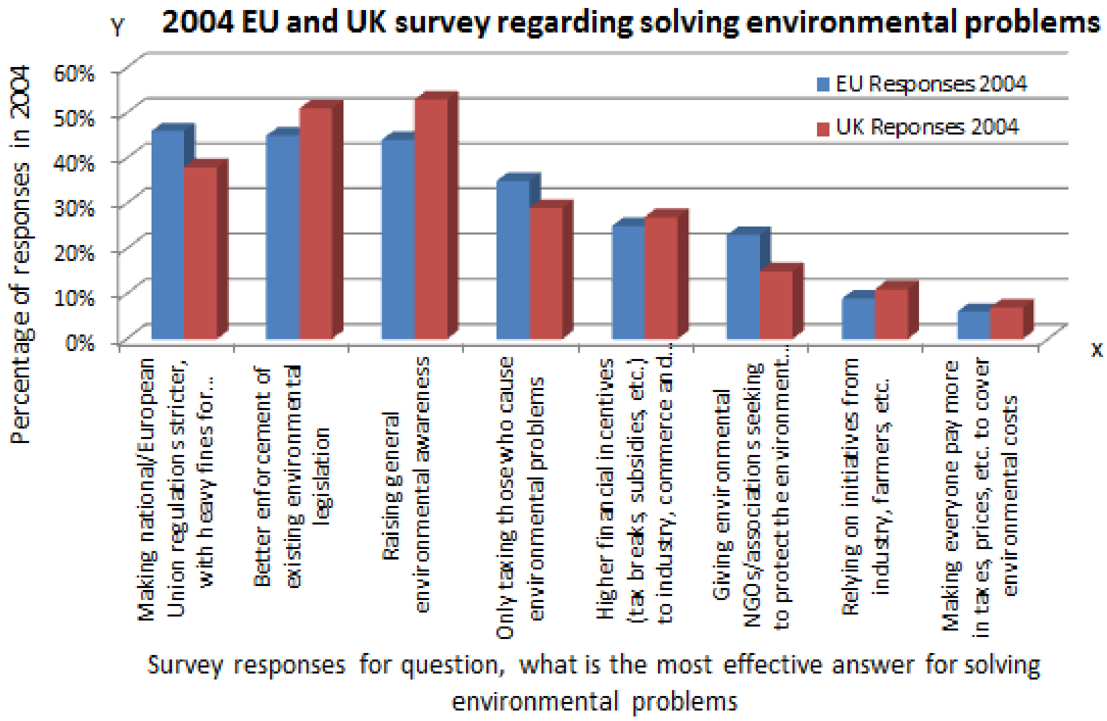

Figure 28: Attitudes survey of European citizens regarding solving environmental problems.

A comparison view of UK and European attitudes to environmental problems.

The UK's perception that existing legislation can improve the environment requires enforcement, which has a diminishing resource. The survey quantifies the approaches by level of education, indicating that the:

> '*Higher the respondent's level of education the more he/she values the importance of making stricter regulations, the enforcement of the implementation of existing legislation and raising general awareness'* (EC, 2004, p37).

This raises the triple helix model around scholar, government and organisation. With the variances in countries, what role does the EU play? The stable pattern answered 33% (p39) of citizens perceive the European Union as being the most suitable level for taking action in this field, although the UK only agree by 18% and prefer localised government control. However the majority agreed that*:*

> *'A vast majority of European citizens would like policy-makers to consider the environment to be just as important as economic or social policies (85%)*' (EC, 2004, p32).

Summary

The survey focused on perception of IAQ, with the intention to understand the political influence of IAQ and the competing demands placed upon local authorities. It became clear that to drive IAQ, the policy makers would influence the visibility and agenda setting. The survey has provided discussion themes, including the perception that IAQ is low compared with more immediate, high risk activities; perception if affected by many factors, including visual stimulus, pleasantness of a smell; interested parties, such as the organic consumers may have a role to play within raising the consciousness, but such information provided to consumers must be accessible and easy to interpret; the EHP predominately play a reactive role within influencing IAQ, responding primarily to occupiers complaints, despite the desire to play a more proactive role in prevention.

5.3 OHS practitioners online survey

The survey was published onto the IOSH training forum on the 15th August 2010 and has continued to remained live. However for the purpose of the below findings, data from the 15th August 2010 until 31st December 2010 were used. Although the survey posting remains on the IOSH website, hit rates started to decline by the beginning of December, and therefore with a sufficient number of responses, I decided to use the data between these dates within my analysis. 475 members viewed the survey with 168 responses (35% response rate). All respondents would have IOSH membership to be able to access the survey data. An analysis of the exploratory data was conducted looking at raw data to decide on their important features. % figures presented represent the % of the 168 respondents. Where applicable, data was grouped to analyse a linear relationship of variables along with excel line, radar and bar charts. The raw data is presented within the appendix for each question to enable future studies. A schematic of the data analysis below:

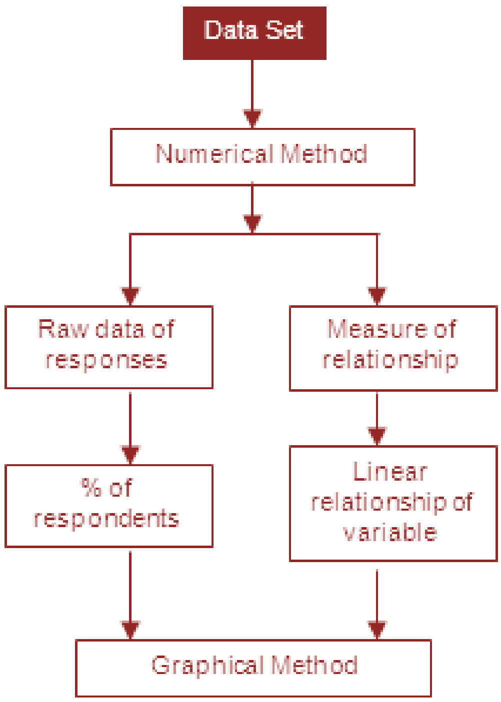

Figure 29: Schematic of the data analysis.

Methodology used to analyse data from the EHO's survey.

General Demographic

147 (88%) of the respondents were OHS practitioners, with 2.5% as CDM Coordinator, 8% as Administration and 1.5% as Human Resources. 100% were members of IOSH, 3% BOHS, 34% other. 117 (70%) of respondents were office based with construction 21% as the second concern. 96 (57%) of occupants are accommodated within a building that is estimated to be 1-5 years old. Which indicates even buildings over 5 years old predominantly have mechanical ventilation. 96 (57%) work within open-plan offices, there is no conclusion drawn from the design of open plan. Pejtersen et al., (2006) claim risks increase due to inadequate air flow and ventilation; whereby Charles et al., (2005) and Veitch et al., (2007) describe an increase in comfort. 79% of respondents have carpeted areas in their workplace, which potentially can increase VOCs from emissions and can harbour fungi and mites.

Question 1: How much time do you spend indoors?

Within table 22, 70% worked in indoor space for more than 91% of their time, which is an increase of Lebowitz and Walkinshaw's (1992) research proportions 80% of individuals within an urban setting spending about 80% of their time indoors.

Table 22: Time spent indoors.

Raw data for number of responses from the OHS practitioner's survey

Time spent indoors						
How much of your time do you spend indoors (approx)?	<10 %	10-25%	26-50%	51-75%	76-90%	>91%
%	0	1	4	3	22	70
Actual	0	2	7	5	36	118

Question 2: Describe your work environment temperature during the majority of occupation?

When asked to indicate their work environment, 56% of occupants described the temperature as ‘uncomfortably fluctuating’, with only 5% stating comfortable. This was further described as variant temperatures (30%) from room to room. Such variances can cause confusion in the body’s ability to self-regulation temperature, thermoregulation..

Wyon (1973) discussed the difference in comfort between big and small temperature swings and proposed that large ambient temperature changes stimulate a body response; whereby small ambient changes stimulate discomfort. This would be an interesting aspect to explore further to understand the degree of difference that stimulates discomfort and the impact on those uncomfortable within their workspace.

Question 3: Are there any unusual odours?

32% of occupants had referred to unsusal odours within their workplace, citing cleaning and solvent smells as their main concern, followed by photocopiers and printers. A few occupants had discussed contaminant odours emitted from the work process entering into office spaces, suggesting the ventilation system from processes and office environments are being mixed and recycled together and fed back into the indoor environment.

Six comments were received that described colleagues perfume as being ‘*overpowering*’, ‘*gives me a headache’* and ‘*annoying*’. In previous chapters, page 15. I have discussed the relationship between smoking and perfume and the lack of knowledge and low risk perception.

> *'The U.S. consumer is as uneducated about the dangers and health risks associated with constant exposure to the chemicals used in synthetic fragrance products as the average non-smoker was to the risks of second-hand smoke. When ignorance is replaced with knowledge, a large segment of the population will respond with a demand for clean and safe air in the workplace'*. (De Vader, 2010, p2).

The key difference between smoking and perfume is the acceptable risk of fragrance. We underestimate the risk, describing fragrance as an annoyance rather than a health risk; Bridges (2002) equated fragrance to second hand smoke in triggering asthma in adults and children; 72% of asthmatics have a negative physical reaction to perfumes (Schim & Williams,1986). Further education and labelling is required to raise the understanding and impact of perfumes.

Question 4: Describe the air?

58% of occupants describe the air as too dry, with 22% only being comfortable. Dry air can demonstrate a higher quantity of air is recycled, which can also increase contaminants that are not filtered, dry air can also result in a raised carbon dioxide levels as air is recycled. Dry air is more noticeable for the occupants, as it can be felt in dry skin, itchy eyes and irritation to nose and throat.

Question 5: Is your work area dusty?

86 said no, which is an indicated there are no additional factors, such as lack of filtration, dusty ductwork, intake fan near pollution source, other industrial activities generating dust or a lack of housekeeping. Although this figure may depend on how frequent cleaning activities were conducted.

Question 6: Do you get static shocks from electricity?

95% of occupants indicated no static shocks. Studies have demonstrated a relationship between reported static shocks and poor indoor air quality (Molina et al., 1989), although not all studies concur (Main and Hogan, 1983). Andresson (1998) states dry air can cause static electricity and can provide another indicator to the quality of the air. Andresson also suggests that stale, odourous air can be another indicator for a dry environment.

Question 7: Does the temperature vary from room to room?

A staggering 90% said temperature does vary from room to room, which when frequently experienced can cause confusion for your body's self-regulation of temperature, as noted by Wyon (1973) as previously discussed. Frontczak and Wargocki (2011) report that thermal comfort is slightly more important than other indoor air factors and perhaps is the most vocalised by occupants.

Question 8: Does the temperature vary during the day?

93% had answered yes. The temperature felt by occupants can be caused by other factors, such as an increase in humidity can make a person feel warmer (Fang, et al., 2004). An increase of carbon dioxide (gas exhaled by respiratory breathing) can increase with lack of adequate ventilation and can also make the occupant feel warmer. Local heating, solar energy and building related activities can increase temperatures experienced by an individual.

Question 9: Are there drafts where you work?

55% have indicated no, 26% said yes. Drafts can be caused by siting occupants underneath ventilation diffusers and/or near open windows and doors. Drafts can reduce satisfaction with the indoor environment (Charles et al., 2005).

Question 10: Do you feel more or less tired in the afternoon?

Epidemiologic studies have indicated tiredness is associated with SBS (Kreiss, 1990) and although I recognise that tiredness can have many contributing factors and are not necessarily IAQ related 66% of the occupants are more tired by the afternoon, suggesting a reduction in productivity. Such internal surveying can assist organisations to identify such factors which following investigation may identify other causes such as workloads or stress.

Question 11: How much control do you have over your environment?

142 respondents(84.5%) described mechanical ventilation provided, with (138) 82% having no control over their mechanical environment. Toftum (2009) discusses occupants within mechanically ventilated spaces and/or those who are unable to control their environment, such as the ability to control a thermostat or open a window, are significantly less satisfied with their environment. Paciuk (1989) and Leman and Bordass (1999) have provided similar commentary by analysing building related symptoms in environments with varied control measures. Although these studies discuss the importance of occupants controlling their own environment, it does highlight the limitations of effective building control. Hoes, et al., (2009) cautions that such behaviour of occupants will impact the thermal processes more than the façade of a building, which may result in an increase of energy consumption, which is the dichotomy of creating a sealed, centrally controlled ventilated building.

Question 12: Have you experienced any of the following symptoms, or have conditions become more acute, that you believe is attributed to indoor air quality ?

0.% nausea 0 % dizziness, 5% irritation of eyes, nose throat, 0.5 breathing problems, 0.5 coughing, 0.5 wheezing, 0% shortness of breath and blurred vision, 1% sinus, 13% dry skin, 0% panic attacks and anxiety, as illustrated in figure 30, page 235.

In contrast to the local authorities survey regarding impact of cognitive conditions, the participanting OHS practitioners have cited headaches (28% of the population responding), migraines (16%), difficulties in concentrating (14%) and 21% experiencing tiredness.

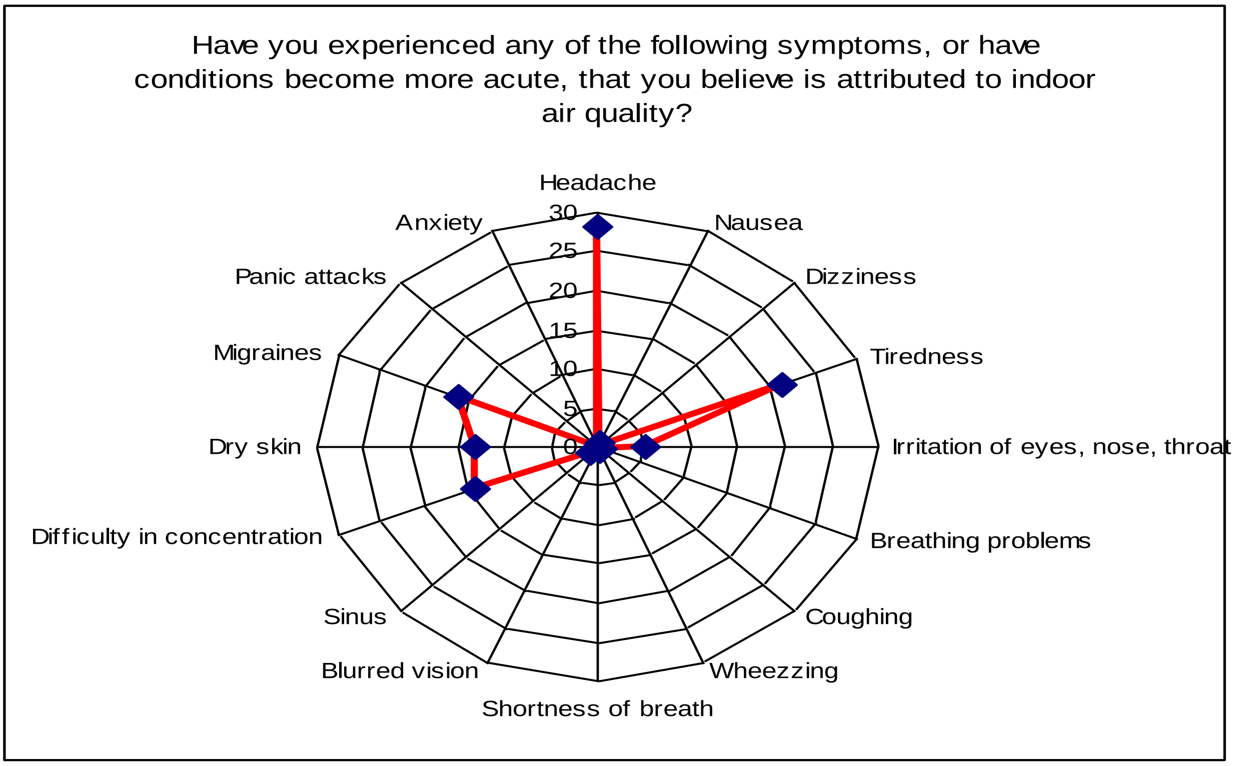

Figure 30: Radar chart of key symptoms believed to be attributed by IAQ Results from OHS practitioner survey of symptoms

These symptoms are consistent with Wargocki et al., (2001) when evaluating symptoms of SBS against air flow rates of 3, 10 and 30 litres per second, per person. The lower the air exchange (3 l/s per person) shows a dramatic increase of mouth dryness and throat dryness, difficulty to think clearly and feeling bad. Wargocki, et al., (2001) directly demonstrated the benefit of increased ventilation rates, although presenting a dichotomy that the cost of increasing ventilation may outweigh the loss of productivity, suggesting sourcing low emission products at building and furnishing stages. Despite my discussion of IAQ cost modelling, caution sould be applied to ensure the ethics of providing a comfortable and healthy environment are balanced.

Question 13: On average how quickly do the symptoms appear once you are in your work area?

Question 14: When do the symptoms go away?

49% of occupants state that their conditions commence after 4 hours within the space and take a minimum of a day for the symptoms to be relieved, as indicated in table 23 and figure 30.

Table 23: Duration of symptoms.

Raw data for number of responses from the OHS practitioner's survey

Duration of symptoms							
On average how quickly do the symptoms appear once you are in your work area?	<1 hour	2-4 hours	> 4 hours	> 1 day	> 1 week	> 1 month	N/A
%	23	10	49	2	0	0	16
When do the symptoms go away?	<1 hour	2-4 hours	> 4 hours	> 1 day	> 1 week	> 1 month	N/A
%	11	5	24	43	0	0	17

As a comparison between these two results, symptoms appear and disappear, we can draw a conclusion that symptoms either initially appear within the first hour, of upto 4 hours of exposure, occupants take longer to recover from their environments.

An exploration of these conditions would be interesting, as to whether they are more psychological (such as headaches and migraines) to physicological.

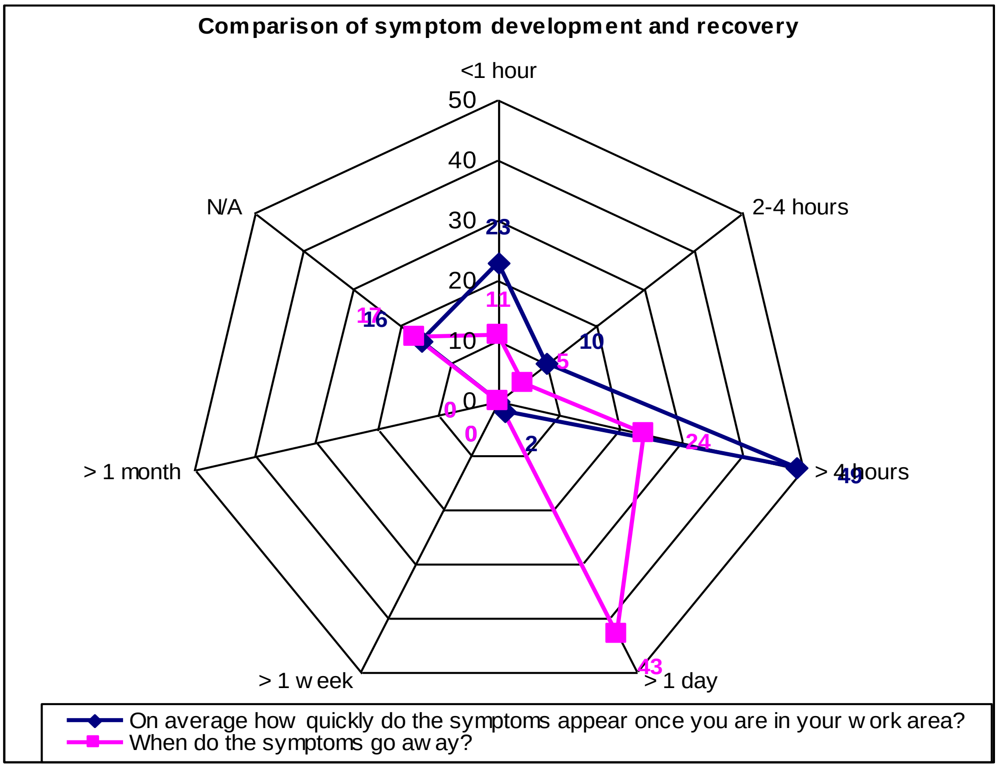

Figure 31: Radar chart comparing duration of symptoms.

A comparison graph depicting comparisons between two OHS practitioner's survey results.

Question 15: Are you aware of other people suffering similar symptoms in your work area?

40% of occupants are aware of their colleagues incurring similar symptoms, with 50% unsure. As this survey did not sample one building, it is difficult to analyse directly with the remaining questions. However it is important to consider within a grouped environment individuals can influence each other's perception.

Question 16: How satisfied are you with your work environment's indoor air quality?

70% of the respondent stated there were not satisfied with their environment. Aside from the associated health effects, dissatisfaction can result in lower productivity (Humphreys and Nicol, 2007, Leaman and Bordass, 2007).

Quantifying dissatisfaction and a measurable reduction in productivity is complicated due to many a myriad of confounding factors which can misrepresent the associations between occupant satisfaction and IAQ factors (Bluyssen, 2010), such as personal, work relationships and social factors (Brown and Cole, 2009).

Questions 17: If known please record the temperature of your workplace; If known please record the carbon dioxide of your workplace; If known please record the humidity of your workplace

Occupants were generally unable to supply details regarding their environment, with only 12% providing temperature readings which range from 16-22°c and 0% data for humidity and carbon dioxide readings. Which suggests there is no active monitoring.

Questions 18: Does your company test the indoor air quality?

If you company does test IAQ, who conducts the survey?

Are the IAQ practitioners registered with any associations?

43% of respondent stated no testing, with 40% unsure. Only 17% test the indoor environment, with 85% of those who do test, conducting the activitiy internally. With the preference for internal monitoring, accessible education is required to ensure testing is conducted correctly and knowledge regarding managing problems are clearly identified. None of the occupants were able to provide any data regarding creditability of practitoners, such as BOHS membership.

Question 19: Do you know who to report problems with indoor air quality to within your organisation?

Limited responses to this question, only 5 text responses were received and they all identified building maintenance as their first source of contact. Not knowing who to report IAQ concerns can compound the situation further by failure to identify health issues.

Question 20: Are IAQ problems acknowledged and managed efficiently?

Only 11% of occupants feel that IAQ problems were acknowledged and managed, with 54% stating no and the remaining 11% unsure. Despite this finding no OHS practitioners had indicated they were reviewing this subject or would further investigate the risk within their own organisation. Question 20 also reflects the lack of ownership and appreciation of IAQ within organisations.

Question 21: How important is indoor air quality to you?

Yet despite the previous two answers, IAQ does have an important factor, as per table 24. Occupants seem aware of the issues, but have taken no action. From my literature review a conclusion can be drawn that despite differences in cultures, countries and political influence, the problems with indoor air quality are the same and despite symptoms felt and perception of IAQ, limited proactive action has been taken by organisations.

Table 24: Importance of IAQ.

Raw data for number of responses from the OHS practitioner's survey.

Importance of IAQ				
How important is indoor air quality to you?	High	Medium	Low	Unsure
%	33	46	14	7

Question 22: Do you have access to resources to help you manage indoor air quality?

The 92% of occupants who have no access to IAQ resources is consistent with the previous answers, 4% indicating unsure and 2% stating yes. No details were provided on the type of resources and sourced locations. This would have been an interesting area to have explored.

Question 23: How much value do you place on educating people about indoor air quality?

Table 25 provides a clear indication the value placed on educating people about IAQ.

Table 25: Value of IAQ.

Raw data for number of responses from the OHS practitioner's survey.

Value of IAQ				
How much value do you place on educating people about indoor air quality?	High	Medium	Low	Unsure
%	75	22	2	1

In comparable views with the EC 2004 survey of citizens, education is the preferred method for raising the agenda of IAQ.

These findings draw a parallel to existing data, including Kostiainen and Lampinen (2008) research, table 26 below:

Table 26: Parallel Kostiainen and Lampinen (2008) research.

Comparable results of Kostiainen and Lampinen (2008) research and the project's OHS practitioner's survey responses.

Kostiainen and Lampinen (2008)	OHS practitioner's Survey
• 78% believe indoor air problems are belittled;	• Only 11% believe IAQ problems are acknowledged and managed;
• 61% believe no one assuming responsibility of IAQ;	• Only 17% confirm indoor air quality testing is conducted;
• 69% are dissatisfied with their workplace;	• 70% - Not satisfied with work environment IAQ;
• 46% complain of unpleasant odour;	• 32% – Unusual odours;
• 25% complain of dry air;	• 58% - Too dry air;
• 52% complain of varying room temperature.	• 56% - Uncomfortable fluctuating temperatures; • 90% - Temperature varies room to room; • 93% - Temperature varies during the day.

Summary

There were no surprises in the data; the OHS practitioner survey has echoed similar findings in existing literature regarding health symptoms. My intention of the survey was not to discover any new findings regarding health symptoms; I was interested in exploring attitudes to IAQ based in their own personal experience. Despite the dissatisfaction with their environments, they were unaware of the IAQ measurements for their own premises; for those who did conduct sampling, only internal readings were taken, which conflicts with the acknowledge lack of information and resources. There has been no pull from the OHS practitioners to establish an agenda of IAQ management, despite declaring a high value (75%) of IAQ education.

5.4 IAQ training certificate findings

The key question underpinning the training certificate was driven by my survey questionnaires, is an accredited certificate an effective method for transferring knowledge and motivation regarding IAQ?

The first training session was run in October 2010 with 5 OHS attendees presented at the IOSH training Centre in Leicestershire, each paying the IOSH course fees of £234.00. Thereafter the course was run three times in 2011 and twice in 2012 and 2013.

During my first session, an IOSH training verifier sat in on the session and evaluated my skills, knowledge and teaching styles. The feedback from IOSH's training verifier did not use any structured approach or models, but did provide feedback as a delegate. The verifier was initially concerned regarding the depth of the course and provided verbal feedback after the first session regarding the '*difficulty level for delegates'*. Having attended their professional certificates previously, I felt the professional training programmes offered by IOSH were designed to stretch the knowledge base of individuals and therefore were designed to be challenging.

Contemplating the critique, I decided to review this feedback upon completion of the delegate's feedback and exam results. With a 100% pass rate and positive feedback, I maintained the level of technical proficiency and introduced more class activities and brainstorming exercises within the sessions to monitor progress of students.

Evaluation of the training is essential to understand the effectiveness of the training delivered and the value in influencing the attendees to transfer their competencies into the workplace to affect the visibility of IAQ in their work environments.

The project activity to design an IAQ training programme is a fundamental activity to demonstrate an outlet to my research and create a forum to exchange information. The project is not intended to provide a full critique of training evaluation models. But despite such views, I am attentive to Goldstein and Ford's (2002) views regarding the careful selection of training evaluation methodology that:

> '*stand or fall on the basis of the adequacy of the criteria chosen' (*Goldstein and Ford, 2002, p143).

There is no one universal method for evaluating training; Kirkpatrick's (1976) four-level model of training evaluation provides a useful foundation for identifying the effectiveness of the training. Kirkpatrick recommends the four levels of reaction (evaluation of attendees' thoughts about the training), learning (results of increased knowledge and skill), behaviour (transfer of knowledge into their job) and results (impact on the workplace from learning). Kirkpatrick's 1976 model has critics as our understanding of the multi-dimensional approach to learning is diverse. Kraiger et al., (1993) questioned whether the four level evaluation model differentiates between skills and facts, since the model measures them with the same assessment tools. Kraiger asserts skills represent the ''how'' of knowledge, whereas facts reflect the "what" of knowledge. Knowing a fact does not always mean that the person has the skills to demonstrate it. This is a fundamental restriction within my evaluation as I am unable to appraise Kirkpatrick's learning, behaviour and results directly. Accepting criticism of the model and the restrictions of my project to evaluate implementation of new knowledge, I have reflected on Goldstein and Ford (2002)'s two pronged model suggests that evaluation focusing on both *outcomes* (summative evaluation) to assess teaching's effectiveness as a development intervention, and *processes* (formative evaluation) to account for the dynamic and customised nature of teaching.

Therefore I intend to explore my skills as a trainer and the transfer of my training to the students as a key outcome to encourage continuous self-learning of the delegates.

Method of review

The last phase of the training was to evaluate the programme to make sure it was sufficient in scope and met the training objectives. This was achieved using two sources of information:

- Knowledge evaluation;
- Participant's feedback.

Knowledge evaluation

I used two key methods for reviewing understanding from participants:

- Revision questions within each element provided in a test format using a range of questioning styles, including open text and multi-choice to enable the student to evaluate their understanding of the subject. Comparable answers were discussed during training and also provided within resource packs.
- Examination following conclusion of training programme to evaluate knowledge. This examination was a 45 minute closed book test using a variety of questioning styles. With 12 questions and 50 marks, a pass rate of 70% was required. An example of the examination paper is included within appendix 12, page 425.

Participant's feedback

A course evaluation form was used at the end of the session for constructive feedback, as shown in appendix 15, page 484. The feedback was positive regarding the content, but reservations were expressed regarding the commercial and people value this would provide.

Upon reflection I had provided a session that addressed the needs from science as opposed to the various commercial disciplines and their motivational requirements; therefore following the first session, I focused on the motivation and cost models of IAQ. Some of the comments below from the IOSH evaluation forms completed by students:

- *‘Really interesting, I have been experiencing problems within my company and this has helped me to understand techniques to identify sources of IAQ problems.’*
- *‘Quite technical, would need some prior knowledge of COSHH.’*
- *‘Would like to see more about IAQ in the home.’*

IOSH forwarded a letter summarising the general feedback from the attendees, as shown within appendix 20, page 492. The IOSH training verifier provided a verbal evaluation of content and delivery to assist with the feedback process. The key comments centred about delivering more practical instructions using the IAQ monitoring equipment, thus to extend this course to two days to allow for practical application of conducting a survey. Currently I have declined this offer, as the majority of my students are self-funded and I believe a 2 day course (at double the cost) would restrict interested parties due to funding; although I would consider a 2 day course as a separate certificate for those who required in-depth knowledge.

Transfer of training

As previously discussed, the most important factor of the course was the introduction of a channel to discuss IAQ and provide informative discussion and debate. Therefore the transfer of competencies into the working environment was critical.

Wolf (1995) criticises specific learning outcomes as a never ending spiral of specifications and as I reflect on the level of competencies within IAQ, a one day certificate provides no justification to the complexity of the subject and therefore the transfer of motivation and interest was critical. Davenport and

Prusak (1998) caution that transmission and absorption of knowledge has no meaning if new knowledge does not lead to some change in behaviour. Exploring Polanyi (2009) explanation of explicit (knowledge captured in manuals, rules and procedures) and tacit (knowledge rooted in an individual's action, experience, values and ideals) ; I do not consider explicit and tacit knowledge as opposing theories, I therefore reflect on how to create a learning environment using explicit knowledge that will facilitate the students to share and develop tacit knowledge.

Bruner (1996) argued that it is the individual's occupational and educational experience which is central and can influence learning. Bruner is clearly stating that knowledge is not just the accepting criteria for transfer of training. Baldwin and Ford (1988) have suggested that student's ability, personality and motivation can influence internalising of training. Robertson and Downs (1979), suggested student's ability might explain about 16% of the variance in training effectiveness; while Noe and Schmitt (1986) stated that student's' motivation and work environment might help explain another 15-20% of the variance of training effectiveness. Tziner et al. (1991) indicated that those with an internal locus of control exhibited higher levels of implementing the training outcomes. Thus indicating differences in personality types who were most effective using their trained skills and transfer strategies, applying those trained skills to the workplace. Therefore to appreciate the significance, the methods for formative assessment will be considered, ensuring the learning outcomes are balanced by providing a framework to encourage further self-learning and reflection from the students. A continuous-learning culture is defined as:

> *`A pattern of shared meanings of perceptions and expectations by all organisational members that constitute an organisational value or belief'* (Tracey *et al*., 1995, p241).

The rationale for IAQ, cost modelling and encouraging group discussions regarding their own workplaces and experiences enabled a bond of shared meanings, perception and learning, which is intended to stimulate self-learning.

Following the delivery of the certificate, I have had a number of students that have requested further details regarding sources of information and access to equipment used.

I have arranged several informal sessions whereby students can visit my workspace to see the IAQ surveying in action (this has been implemented with no commercial benefits or profits). I have also been requested to deliver sessions in Ireland for a group of IOSH members who are unable to travel to the UK. There were no direct, measured changes from the training, therefore the exploration of influencing, practice, transfer of knowledge requires further assessing. However the intention to influence attendees on the importance of IAQ has been achieved and I have viewed this as a positive medium for debate and communication.

In May 2013, I was approached by the Northern Ireland IOSH committee chair requesting an abridged awareness training session of IAQ to be presented to their 150 members. At the time of writing this document, an abstract and presentation overview is being prepared for discussion, with a date in February 2014 agreed. As previously discussed in this chapter, due to the limited time of IOSH's training session, stimulating an interest in IAQ will underpin the content of the session to encourage self-learning from the attendees.

5.5 IAQ website feedback

Following completion of the website and registration to search engines, I started to trend the traffic on the site from May 2010 until March 2011, table 27. Trending of the site provided an evaluation as to the interest of IAQ, and specifically what pages users were accessing; the trend provided sources of traffic (such as search engines or direct links). Such data is important when reviewing most effective method for raising the agenda of IAQ.

Table 27: IAQUK website hits per month.

Number of hits on the IAQUK website during May 2010 to March 2011.

IAQUK website hits per month	
Hits per month	
Hits	Month
9115	Mar-11
8782	Feb-11
6255	Jan-11
4619	Dec-10
5821	Nov-10
7541	Oct-10
7224	Sep-10
6010	Aug-10
8166	Jul-10
487	Jun-10
212	May-10

The data has been provided by the internet provider, via an online statistical tool that accompanied the website portal design package. The tool enabled me to review hits, total number of visitors to the site and webpages receiving the highest traffic. Tables displaying % figures include the data from May 2010 to March 2011. The hit counter table demonstrates the IAQUK site has substantially increased in interest, despite no advertising or promoting, aside from registering the site with key search engines. Unfortunately I am unable to appraise whether the users are returning users, but such a growth pattern indicates a degree of satisfaction and usable data. Analysing days of the week, Sunday equated to 32% of activity, closely followed by Saturday 13% of web hits. The hours between 13.00 - 16.00 hours saw the highest traffic usage. The data provides an understanding that the users may be accessing during personal time. Upon reviewing the statistics from the website, the number of hits had gradually increased, with a slight drop around the Christmas period.

Since completing this trend analysis, I reviewed 12 months of data again in November 2012 and although no advertising has taken place, the figures have jumped to an average of 17,634 monthly hits. When using a web tracking website called Visitors Worth (2012) I compared my hits counter with existing websites, such as the Environment Agency (303,824 pages viewed monthly) and HSE (765,166 hits monthly) the IAQUK ranking is considerably less. Whilst reviewing the US EPA figures, on Visitors Worth, of 3.9 million pages hit, within their top ten trending for key word searches, mould (ranked 4th at 3.60%), radon (ranked 5th at 3.16%), air duct cleaning (ranked 7th at 2.20%), mould removal (ranked 8th at 2.01%) and duct cleaning (ranked 10th at 1.86%) were the most searched and visited sites, accounting for half of all searches, total 12.83% of visitors to their site. This is an interesting trend; visitors may not necessary use the term IAQ to search for information, but are generally looking for a specific piece of information; therefore imbedding the term IAQ into the public domain and being attentive to the use of an acronym without description has significance.
The Visitors Worth website is unable to offer stats on the IAQUK website due to the limited number of hits, however I intend to explore this further within the statistical software within the web tool platform.

An interesting factor of users stimulated the next question regarding sources of hits, as per table 28.

Table 28: IAQUK website hits per month.
Location of hits on the IAQUK website during May 2010 to March 2011.

IAQUK website hits by country		
Hits by Country		
1	56.65%	US Commercial
2	23.69%	Unresolved/Unknown
3	5.96%	Network
4	2.66%	Non-Profit Organisation
5	2.68%	United Kingdom
6	2.01%	Russian Federation
7	1.10%	Thailand
8	1.24%	United States
9	1.07%	Czech Republic
10	1.19%	Canada
11	0.92%	Egypt
12	0.83%	Japan

Using Visitors Worth, within the US EPA trends, only 61% of users were from the US, Indian accounted for 9% of their visited (ranked 2nd) , followed by the Canada at 2.4% and the UK at 2.0%. A similar pattern emerged looking at the HSE website, whereby 53.3% of visitors were from the UK, 7.9% were from India (ranked 2nd). The Environment Agency indicated 82.1% UK and ranked second country India 3.9% of visitors. This may be due to the colonial links and legislation legacy, but it does demonstrate the audience can be broader than UK interests and websites can be used as a method for sharing data and best practices. Interestingly, the hits on IAQUK by countries have revealed that most of the traffic has been directed from the

US, although there is a curious trend with Russian, Thailand, Egypt and Japan. Such data provides an interesting correlation with the Google trend stats.

Legislation of indoor air in Russia are part of the Russian Federation legal system and are secured in the Constitution. The air quality is controlled by the Goscomgidromet (state committee for atmospheric and earth science) and the Sunepidnadzor (The Sanitary Epidemiological services). In compliance with these laws everybody has the right to a favourable environment and the duty to protect, preserve and maintain it (Bitkolov and Musijchuk, 1997). Although many of the statutes are determined by protection from radioactive contaminants and biological pollutants, clearly indicating a history of external air quality that has evolved to consider indoor air, which has been boosted by the review of cigarette smoking. Upon a search using a variety of Russian search engines including Yandex, reviewing Крытый организации качества воздуха (indoor air quality organisations); there was limited data to access, aside from commercial companies offering mechanical ventilation systems.

The MSTE, Thailand's Ministry of Science, Technology and Environment, Pollution Control Department provide a range of environmental data, including indoor and concerns regarding indoor odours.
Although, the information is limited and concentrates on the statistical degree of the concerns; rather than practical solutions and information to support engagement with IAQ at localised levels.

Indoor air quality is slowly gaining prominence in the Czech Republic. This has been driven by external air pollution, particularly as Moravia-Silesia and north Bohemia producing the highest pollution levels, with 14 of the 20 country's coal fuelled power plants within their regions (Novakova, 2009).
Occupational Safety Information and Education Centre (CIVOP) in Czech Republic, manage health and safety, but a search of their site sourcing kvality ovzduší (air quality) was limited, with links to alternative sites,

particularly within the US. Limited resources were sourced for IAQ within Egypt from Government organisation despite extensive papers researching air quality within Cairo. The majority of search results were sourced from commercial HVAC companies and interestingly from blog sources. Links for external sources were published, which seem to be redirecting mainly to the Middle East, in particular the University of Qatar that offers a unit within their degree programme for IAQ. NIIS (National Institute of Industrial Safety) in Japan manage occupational safety; however 室内空気質 (indoor air quality) is managed by three key bodies, the Ministry of Health, Building Management Education Center and Tokyo Health Safety Centre working to prevent Hoyaku (sick building syndrome) in the form of guidance and building control documents. Maintenance of Sanitation in Buildings Act 1970 (Ministry of Health, Labour and Welfare in Japan, 1970) governs the competencies of Building Environmental Health Management Engineers whereby engineers are required to pass a national examination conducted by the building manager of environmental sanitation, to achieve a diploma prior to practising. There are substantial resources contained on these sites, however again the information relates to standards rather than advice for OHS practitioners, building owners, which presents a silo of knowledge. There is no website that provides collective data of resources, guidance and legislation and is dedicated to IAQ.

IAQUK will be the first in the UK, and potentially globally. With this view, general information that has a broader application (such as discussing topics, formaldehyde or ventilation) can be discussed in a generic dialogue, with links to relevant country legislation/guidance.

The platform that IAQUK has been accessed from provides an understanding regarding the visibility of the site and although it is expected that the predominant search engines of Google, Yahoo and Bing, it is interesting to see direct contact which rates as the highest connection, indicating individuals are using the direct domain link or accessing via an alternatively sourced link. Google.com has a higher status to Google.co.uk, confirming international, US, access over UK users, table 29.

Table 29: IAQUK website hits via access platform.

Access platform sources for hits on the IAQUK website during May 2010 to March 2011.

IAQUK website hits via access platform		
Accessed via		
1	56.65%	Direct Access
2	23.69%	Google.com
3	8.36%	Yahoo.com
4	5.96%	Bing.com
5	2.66%	Google.co.uk
6	2.68%	Other search engines

Within the search engines I have been able to trend key word searches that have provided a link to the IAQUK website, table 30. Totally the 43.35% traffic from search engines, the following five key word searches have been identified, 27.32% used the search word formaldehyde, 17.84% searched humidity, 15.93% temperature, 14.97% odours and 5.71% acetone. This demonstrates, as with the EPA trend statistics, visitors are searching for specific data.

Table 30: IAQUK website pages visited.

Location of hits on the IAQUK website during May 2010 to March 2011.

IAQUK website pages visited

Pages Visited		
1	74.32%	Resources
2	12.39%	In the Home
3	5.18%	Training
4	4.67%	About Us
5	3.44%	Other

Understanding pages visited provides insight into understanding the audience needs and being able to access a free resource seem to dominate the rationale. Interestingly I have been able to break the resources page for further analyses and found perfume consistent as usage, accumulating to 68% of traffic. The temperature page varied according to the season, but increased during the summer season, therefore debating the acceptability to colder climates compared with warmer. Many individuals have accessed 'in the home' interactive resource provided by the US EPA which creates a profile of personal users; and may provide further debate regarding marketing the field of IAQ to existing individuals who are concerned about the chemicals in our food and environment.

As discussed within my project activities, the design of the website is important to increase website traffic, but also to sustain hit numbers and encourage returning visitors. Tarafdar and Zhang (2008) discuss the content of the website as critical for the continued use by browsers:

- The range of information (variety of topics) is high;
- The information is applicable to the website's activities;
- The information is detailed;
- The information is current;
- The information is accurate;
- It is easy to locate the information;
- The information is useful;
- The information is systematically organized;

- The meaning of the information is clear;
- The layout of the information is easy to understand.

(Tarafdar and Zhang, 2008, p19).

I intend to maintain and grow this site and therefore feedback is critical to ensure the site has a value. Within the website, I included a feedback form for visitors asking for details regarding how easy they had found the website to navigate, whether they found the information they were seeking, what content was most useful, which content was less useful and any further comments. I received 32 feedback forms, with 100% agreeing the website was easy to navigate, finding the information they were seeking. Out of the 32 responses selecting most useful pages of the website were resources (21 visitors), in the home (7 visitors), training (2 visitors), about IAQ (1 visitor) and news and events (1 visitor). The results reflect the hits per page. Many visitors did not select a comment regarding least useful, but those that did (6 visitors) indicated 100% that finding a practitioner was the least useful page. Since publication of the site onto the intranet, I have received comments from users requesting information.

The majority of requests have related to a personal concern in the home.

- *'I have mould on my wall in the kitchen, can you help?'*
- *'I moved to a new house 18 months ago and have developed a cough which won't go away'.*
- *'I think I have asthma because of my house'.*
- *'I have started to get a reaction to perfume, can you provide more information'.*

I have had a few queries details of the IAQ training course; and some comments regarding finding an occupational hygienist for monitoring activities. Such feedback suggests that individuals are accessing the site for informative content with a focus on hazards in the home which may have been triggered by an event (reaction to their indoor environment). Which raises questions for discussion regarding what lessons can be drawn from understanding societal concerns of risk and how can we influence change around perception of risk and consumer purchase habits?

Despite completion of my OHS practitioner survey, I have left my survey questions on the website to encourage engagement with users and to gather data for future analysis.

5.6 Action Research Reflection

As discussed within my methodology section, figure 8, page 139, regarding action research and the layer events that shaped my project, I have provided below further dialogue on my reflective points.

Project action research events identified:

a) Initial concept for project defines literature search strategy.

- At the start of my DProf project I commenced with a global view of raising the knowledge and understanding of IAQ, which had been stimulated from my MSc project with Middlesex University in 2007; however the specifics of methodology, project activities and aims and objectives were unclear and throughout the first stages of my project actions, these changed and evolved as active learning was applied.
- Reviewing my journal auto-ethnography account at this stage, I felt I should have known the specifics of my project and questioned my role within the programme, recognising the distinction of MSc to DProf, a crisis in confidence followed (Schön, 1983). To compensate for my lack of direction, I began to embrace and immerse myself into the IAQ arena. Engaging in this process enabled me to focus on my experiences and identity as an academic practitioner, which required openness and reflexivity (Holloway & Freshwater, 2007).
- I drew comfort from Fillery-Travis' (2012) account of both academic advisor and DProf student sharing uncertainty regarding the programme plan:

‘*Throughout this process the advisor is not an expert in the organisational context or in the multi-disciplinary focus of the candidate’s work. The advisor is required to sit with a relatively high degree of ambiguity and uncertainty as they cannot control or dictate the learning sought or achieved by the candidate. The candidate is also experiencing appropriate uncertainty in relation to the development and progress of their programme. The uncertainty of the candidate and the advisor is shared, albeit from different perspectives’* (Fillery-Travis, 2012, p6).

- Acceptance of my uncertainties enabled me to embrace an eclectic literature review.

b) Literature review exploring application of IAQ.

- The literature review brought context to my active learning, particularly enabling me to explore historical context, cost effectiveness, political, social and economic influence and the impact of new contaminants such as perfumes. Such breadth of literature had an inclusion value, which enabled me to identify key stakeholders to engage within this project and provided structure to understanding my aims and objectives. During this stage I started to draft thesis abstracts and redefine compositions topical conversations to explore.

c) Project aims and objectives defined by literature review.

- The project aims and objectives assisted with refining my project direction; however this stage was frequently reviewed during my project and revised several times as my knowledge from the continuous literature review activities expanded.

- Throughout this stage, I developed my knowledge of methodology applications, action research, quantitative and qualitative paradigms, pragmatism, critical analysis and reflective practice. I also started to explore my role within the research, Costely (2011) discussed DProf students as:

'M*uch less likely to be interested in pursuing research as an end in itself or contributing to the stock of academic knowledge than to using an enquiring and innovative approach to practice and producing knowledge that has direct application to their professional endeavours'* (Costely, 2011, p2).

d) Survey questions and target population shaped by findings from the literature review.

- The literature review and associated composition topics defined the structure of questions and enabled me to understand the push/pull effect of local authorities and OHS practitioners as a target population for participants.
- I was interested to explore issues such as management of IAQ, awareness and influences. A pre-test enabled me to refine these questions, in particular understanding the economic and political context.

e) Quantitative data from surveys gathered and analysed.

- The literature review had assisted in deciding the chosen methodology for data analysis. Following a review of the raw data, ratings were applied to the answers to calculate standard mean, data was grouped to analyse a linear relationship of variables.
- The two surveys were compared for common themes. Variables with significant interest, such as risk perception, knowledge and management of IAQ were included within my discussion section.

f) **Survey data triangulated with literature review developing key themes.**

- The data was gathered and grouped to create composite circles of topical content and compare with my literature review. This activity prompted further discussions with the literature review and stimulated the need for further dialogue within my discussions chapter. The results were also compared with existing literature research surveying occupants.
- The results from the survey and literature review enabled me to contour my aims and objectives and understand the requirements for a website portal and training certificate.

g) **Define project activities (website and training) shaped by survey and literature review.**

- The findings from the surveys and literature defined the process for developing a website portal, choosing a free media platform, as opposed to a book that was originally discussed within my first programme plan, understanding that transferability of the IAQ agenda has an association with easy accessibility.
- The website was also designed for both technical and lay readers creating a push - pull resource. The action research stage also enabled me to focus on a suitable method for training, a vehicle for delivering an accredited programme through IOSH and a suitable syllabus/content.
- The findings from the survey and literature review also provided the basis for the content and method of delivery for a training programme. Within the literature research I reviewed existing global IAQ training certificates and explored UK associated training, such as environmental, occupational hygiene, facility management and methods of delivery via distance, classroom and e-learning.

- The survey provided a clear understanding of the existing knowledge of both OHS practitioners and local authorities. A clear epiphany was the lack of understanding and perception of IAQ matters.

h) Collate qualitative feedback from project activities and triangulate with survey and literature.

- To provide a comprehensive view, I triangulated findings from the literature review, surveys, website feedback and training evaluations to engage further depth and richness to my discussions and recommendations.

i) Compile findings and introduce further discussions within chapter 6.

- The most challenging aspect for discussion was the original boundaries of my aims and objectives and frequently they were reviewed to ensure my paper provided a true representation of the IAQ agenda in a real world environment.

5.7 Triangulation and Transformative Activities

An integral application of using multi-methods of research is the triangulation of data to provide a rich context of findings. Denzin (1978) defines triangulation as:

> *'The combination of methodologies in the study of the same phenomenon'* (Denzin, 1978, p291).

Triangulation has a historical application of combined quantify and qualify data, validating findings in a reliable framework. However for the purpose of my project, I am not seeking to evaluate a hypothesis, nor identify a specific answer that requires a resolution; my purpose for selecting the triangulation method was to allow an opportunity to blend understanding from various viewpoints, including the diversity of key stakeholders:

- Strategic – EU, Government, Policy Makers;
- Implementation – OHS practitioners, local authorities;
- Operation – Consumers, Organisation.

The application of findings from my project provides a dialogue of learning between literature research, Local Authority and OHS practitioner surveys, developing IAQ awareness and evaluation of resources, in particular the IAQ website portal.

Unlike the traditional application of selecting triangulation to validate my findings, I recognise there is no final conclusion, merely an organisation of thoughts to bridge a silo debate into a more coherent topic, with intentions to stimulate further dialogue. Allowing a holistic approach that overlaps variances and highlights gaps in the knowledge of IAQ will provide a contextual analysis to enable me to reflect throughout this project and draw a conclusion of recommendations for future research.

Jick (1970) succinctly described a holistic feel within triangulation methods:

> '*While one can rely on certain scientific conventions (e.g., scaling, control groups, etc.) for maximizing the credibility of one's findings, the researcher using triangulation is likely to rely still more on a "feel" of the situation. This intuition and first-hand knowledge drawn from the multiple vantage points is centrally reflected in the interpretation process'* (Jick, 1970, p608).

Whilst traversing the findings and reflections throughout the DProf project with a clear focus on the horizon to lead IAQ into industry, understanding stakeholder's criteria, an intuitive empathy and understanding is not discounted from this project

The use of surveying local authorities and OHS practitioners provides an insight to the perception and impact of IAQ and the resources to support future developments within this field. From the surveys and literature review, I compiled significant data into four categories to assist with transferring findings into a useable format, as per table 31 below.

Table 31: Category of Topics.

Results from the EHP and OHS practitioner survey triangulated into topics.

Risk Perception	Compentency / Knowledge	Environment	Resources
•Response rate of EHP survey 34%; •Response rate of practitioners survey 35% ; •Visual stimulus to an odour source can increase unacceptability of activity; •Risks that are perceived as familiar, voluntary, natural or under an individual's control are more accepted than risks perceived to be unfamiliar, involuntary or exotic ; •IAQ ranked a low prioriy of health concerns from local authorities; •Cognitive/mental health conditions are not recognised in the IAQ debate; •Local Authorities saw comfort and productivity were seen as negligible in IAQ terms; •There is a difference between what is perceived as a risk and what is an actual risk.	•Significantly higher value placed on educating people about IAQ; •Lack of understanding regarding new topics of concerns such as odours and perfume; •Lack of understanding about correlation of topics, such as VOCs and perfumes.	•70% of practitioners expressed that they were not satisifed with their environemt ; •54% of practitioners state air quality not acknowledged in their workplace; •Inadequate ventilation is seen as the most significant cause of indoor air quality; •The performance of the building is more important than the occupants; •Local Authorities only survey IAQ following a complaint; •32% indicated reasonable to significant health concerns for mechanically ventilated buildings; •29% for naturally ventilated buildings; •56% of practitioners described the temperature in their environment as uncomfortably fluctuating; •32% of practitioners had experiences of unusual odours in their workplace.	•Only 17% of practitioners test the indoor environment ; •92% of practitioners have no access to indoor air quality resources; •86% of adult internet users have researched for health information on the intranet ; •Significant value was placed on accessible resources.

Qualitative data and analysis acts as the binding agent of my project, the interpretation of the findings triangulated defines key themes and allows for further dialogue, thus enriching the research. Jick (1979) describes the process to:

'*Illuminate behavior in context' (*Jick. 1979, p609).

To ensure the key themes do not become silo topics, I reflect on my boundary questions for my project with the intention of integrating a common thread:

- What is the current visibility of IAQ in the UK?
- What are the gaps between knowledge, government policy, cost effectiveness, risk comparison and practical application?
- What recommendations would be required to heighten the awareness and knowledge of key stakeholders?

Through this blending and integration of data I identify discussion points, as illustrated in figure 32, for chapter 6.

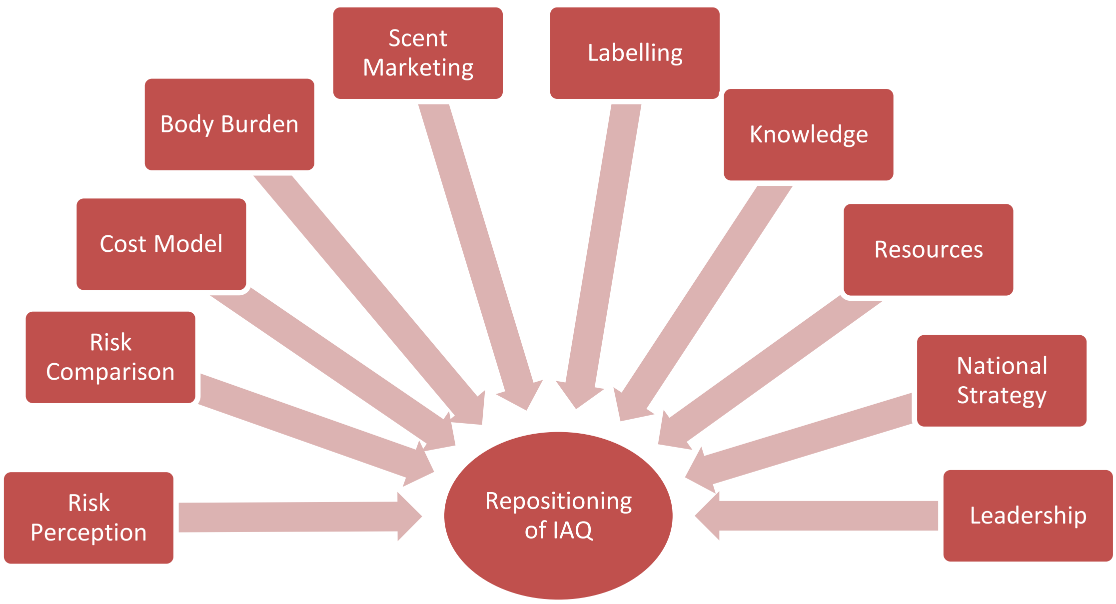

Figure 32: Illustration of IAQ themes.

Key themes identified from triangulation for discussion within project.

To summarise key learning points, the review of the Government's £43m investment to the Smoke Free campaign has produced limited results, although legislation has reduced the impact of secondary smoke. Despite being an educated society, smokers have decided to accept the risk of the latent health effects of smoking; therefore the campaign has failed to address the needs of their audience, particularly understanding their reasons for continuing to smoke, where psychological dependency or an addiction.

Within the surveys conducted, there is a general acknowledgement of IAQ, mainly from negative personal experience or complaints from occupants; however despite this acknowledgement, there is no ownership of the concerns, no action taken and no plans to investigate further. Explaining the campaign around smoking, IAQ has to be personal and people need to feel a personal connection/rationale for stimulating interest and adapting behaviour. There is a reoccurring theme throughout both surveys of a dissatisfaction of indoor environment, a lack of ownership and skills to manage at localised level, which is compounded by the limited understanding of health, comfort and productivity impact and the financial cost effectiveness correlation. Despite the pessimistic views, the value placed on resources for transferring knowledge into a practical setting was evident and highly valued. The questionnaire emphasised the nature of risk perception and that profiled campaigns, such as smoking, obesity, drinking and external environmental pollution had a perceived higher value, which might be due to the social impact and the associated costs to society; as previously discussed, the stimulus, our senses, also have a greater professed risk factor.

Exploring attitudes should assist with deliver of changing IAQ culture; the general public have a higher concern by the EC (2004) report, which would require exploring to understand whether such concerns are driven by associated movements of organic food and natural products. Can a consumer market consciously drive IAQ?

Research regarding the silo components has been extensively discussed, lack of multi-pollutant data, silo topics, body burden; however the application of theory within organisations and the practical considerations is essential information in defining and framing various risk characterisation aspects, policy decisions, cost effectiveness, risk comparison and influencing change, ensuring an interplay and co-operation between science, society, policy, and stakeholders. I have discussed such permutations within chapters 6 and 7.

There are significant issues in this interface, such as the need for enhanced resources and communication of IAQ in a transferable format to those who need it, ask for it, or have the right to know about it. Matanoski (2001) discusses the disjointed approach between policy makers and the scientific community, with policy makers not perceiving the research community as the producer of relevant information for decision-making processes.

This view is also echoed by Samet and Lee (2001), who affirm interface between the players is often under-developed or functions poorly.

Lahtinen et al., (2004) indicate that the solution to indoor air problems is not solely a technical question but also involves management of social interactions and cooperation. Thereby expressing that management interaction policy and education can be significant in managing indoor air quality; which is my intention to explore within the next chapter.

5.8 Conclusions

Chapter 5 provides a summary of findings from my literature research and project activities and suggests further discussions identified from the triangulation of data compiled within the boundaries of my project dialogue. There are two key epiphanies within the development of IAQ awareness and resources:

- Know your audience and the diverse method for communicating;
- Motivation of IAQ, to understand that the resources/training material used are about influencing and not just providing technical knowledge. Thus stimulating the drive to develop self-learning in an individual to increase understanding of IAQ.

To reach the anticipated objectives of this project, capacity building of a range of audiences, from technical, policy-makers, building related industries, enforcement bodies to the lay reader, is critical with the purpose of sharing expertise and resources to accomplish a common goal. Using established structures of the IOSH CPD training programme to offer accredited training to an existing client base and the use of internet based information to provide an accessible portal, I am also able to use these tools to understand the risk perception and underpinning interests that stimulate the subject matter, thus providing further resources to influence and context frame IAQ accordingly. Aside from the application of a working environment, it has become evident through the surveys, training and internet resources that a personal relationship with IAQ is required to stimulate interest; therefore discussing IAQ in the context of hazards in the home, perfume and scent marketing and publishing such information on social media platforms can assist with driving a pull from consumers to debate choices regarding their environment; thus creating a risk intelligent society that can fuel change.

The Office of Disease Prevention and Health Promotion (2010) describe the essential requirement for effective communication to promote health and to raise awareness of risks and solutions, thus stimulating motivation and skills needed to reduce risk at source.

For over 150 years we have recognised the relationship between indoor air quality and comfort, health and productivity. Since the 1970s the focus has increased due to sealed buildings, an increase of time spent indoors and the occupancy density and the increase of artificial products used within. Since the 1970s a shift towards monitoring and establishing guidelines has provided reference with regards to exposure levels, ventilation rates and understanding of IAQ sources via toxicological, epidemiological and statistical criteria.

Despite the extent of data, often the topics are explored in silos which create difficulties in understanding mixtures of components and body burden of such concoctions. Even with limited combined studies, there is negligible dispute that indoor air quality is a growing concern and the current policies and activities have failed to raise the agenda. Reflecting on the pensive points of Rost (1993) resonant in my reflective epiphany that a leader needs to echo their followers:

> *'Leadership is an influence relationship among leaders and followers who intend real changes that reflect their shared purposes' (*Rost, 1993, p102*).*

IAQ leadership in pursuit of optimum effectiveness; and understanding, traversing and embracing the myriad silos according to the situation and environment, requires self-awareness and reflection. Leadership and coordination between organisations is absent; a critical lens to understand the failure of IAQ integration is required.

I contemplate my recent trajectory towards distance leadership within a subject matter; particularly with regards to educating, transforming knowledge into practice and influencing change within IAQ.

With the development of interacting within a global, often virtual, society, the skill to influence at a distance and translate to diverse cultures, mediums and political/organisational requirements will challenge my role in continuing this dialogue.

The communication of IAQ research has been broadcasted to extensively a scientific audience, using traditional methods of dissemination. IAQ is multi-disciplinary with a broad range of stakeholders. Without an in-depth appreciation of the interwoven nature of these relationships and definite actions to motivate and stimulate debate, the likelihood is that our sleeping giant will continue to grow.

The most arduous task of this project has been the restrictions to remain within the boundaries of my project objectives. The extensive reading with the IAQ arena has raised further questions for me to explore the permutations of this woven sphere. Therefore I have continued further discussions within Chapter 6 mainly to broaden my own passion to continue this literature; but also in anticipation that the reader will seek to explore some of the topics discussed within this project.

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Chapter 6 - Discussion

6.1 Introduction

Following my evaluation of my findings within Chapter 5, the triangulation of data has identified further permutations to the boundaries of my project dialogue; and therefore to ensure an inclusive view is encapsulated within this project, I have provided an additional chapter for discussion to stimulate further debate.

At the start of my project, I had a fixed view regarding the key issues of IAQ and the importance of effective IAQ management; however the surveys and literature review has shaped my project to provide many layers in understanding how to raise the visibility of IAQ in the UK. Naively I had started this journey with the intention of gathering compelling data to support the positioning of IAQ within Government and organisations. But such a one dimensional, idealistic view would have contributed minimally to the existing debate. Numerous papers have presented such compelling evidence of health, productivity and performance impact, few have discussed the complexities of application in a real world environment.

Chapter 6 provides a parallel discussion regarding topics which I considered integral to the conversation of contextualising the setting and positioning of IAQ; including an exploration of risk comparison, examining the legal and ethical rationale in compliance and debating whether low risk can be considered safe using the risk tolerability framework; considering further the perceived low risk of perfumes and air quality contaminants within our environments and the body burden effects.

During the past five years of my programme, I have immersed into the IAQ arena and engaged in infinite conversations with friends, family members, professional peers and indeed even empathetic strangers; and without exception the majority of the conversations have led to enquiries regarding perfumes and their impact. I had not considered scent as an important topical factor at the beginning of my project, but such dialogue has provided an insight into understanding how IAQ can be translated to the general public using perfumes and scents. Scent appears to be a subject people can relate to and understand, they have had positive and negative experiences with scents, but all experiences have value that provide the interested party an ability to identify with IAQ as a topic and explore the criteria for influencing change.

Finally within this chapter I discuss my project and the effectiveness and limitations of my methodology and project activities, reflecting on my own learning and perception.

6.2 Risk Management - Is risk compliance or self-regulation a driver for IAQ implementation within businesses?

Evaluation of the surveys and literature review stimulate debate regarding the perception of risk, particularly when comparing a latent, low risk hazard (such as IAQ) to an immediate hazard (falling from heights). The discussions are further complicated by the stimulus of a risk and how such risks interact with our senses. Due to the latent, often acceptable stimulus (such as perfumes), can a risk be tolerable? From my literature, legislation is unlikely to raise the debate of IAQ, therefore is self-regulation acceptable? Such questions assist with the exploration of how to raise the visibility of IAQ in the UK.

Tolerable risk

In traditional quantitative risk analysis, health risks are measured and, often implicitly, compared in terms of mortality and economical risk. Indeed risk management criteria are often drawn from the tolerability of risk framework model HSE (2001), figure 33. Risks that are estimated to be greater than 10^4 to the general public and 10^3 in the occupational sector are considered '*unacceptable*'. Risks that fall between 10^4 to 10^6 for the public and 10^3 to 10^6 for industry are termed within the '*tolerable*' region. Risks under 10^6 are deemed '*acceptable*'.

> '*A lower bound below which risks are regarded as being "broadly acceptable" and therefore requiring no significant action to effect further reduction'*. (SCEA, 2006, p21).

Communicating the meaning of 10^6 and the definition of "acceptable risk" has a significant effect on scientific, social and economic risk acceptability.

Therefore it would seem appropriate to explore the reasoning behind the criteria for 10^6 and the understanding how the benefits of 10^6 outweigh the costs.

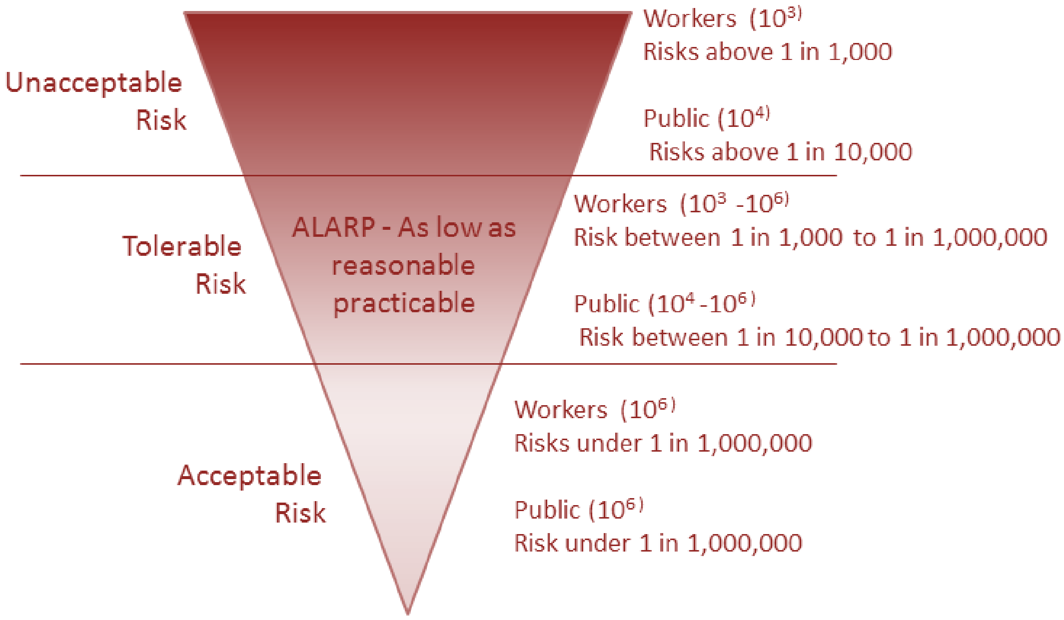

Figure 33: Interpretation of the ALARP Model.

An illustration of the 'as low as reasonably practicable' (ALARP) model used by the HSE.

The origins for the parameters of quantifiable tolerability of 10^6 were historically an arbitrary number. Mantel and Bryan (1961) scientists from the National Cancer Institute defined the parameters of safety testing; summarising 'safe' is equal to 1 chance in 1,000,000 of developing cancer. An investigation by Kelly (1991) asked how the number of one in one hundred million was formulated, Mantel replied,

> '*We just pulled it out of a hat. After all, defining safe was not the focus of their article*' (Kelly, 1991, p4).

But despite such commentary the origins of 10^6 was formed. The US Food and Drug Administration adopted the 10^6 in 1973 and were thus established as the maximum lifetime risk that is essentially zero, or the level below which no further regulatory consideration would be given (USFDA, 1973).

The 10^6 parameters were eventually adopted by the World Health Organization and other various global bodies, including the HSE. The government's view not to impose red tape legislation and to adopt a flexible self-imposed regulatory standard is prevalent in the Government's Deregulations Unit.

> '*In theory, deregulation would not only relieve burdens on British industry and make it more competitive but also reduce the work of HSE and other regulatory agencies (and thereby Government costs'* (DTI, 2005, p14).

Could, therefore, the 10^6 boundary be seen by government as a broader tool to bring competitive advantage in deregulation? In November 2006, the first report from the Better Regulation Commission was published focusing on the:

> '*Growing disquiet about the management of risk in society and what is seen by many as a rising tide of regulation, exacerbated by periodic inappropriate responses to 'risks of the day'* (BRC, 2006, p3).

The HSE described the broadly acceptable region, 10^6, within their Tolerability of Risk framework as:

> '*Insignificant or trivial'*, clarifying that '*they are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produced very low risks*' (HSE, 2001, p114).

The apparent rational framework for assessing the economic impact of risk acceptance in many instances would be difficult to measure precisely and to declare with certainty that money not spent in one area, may not affect the economy of another area.

This therefore questions the economic value of the 10^6 theory and whether there is a need to include an acceptable boundary. Although there is an acceptance to adopting a strategy for managing risks, should trivial risks be considered insignificant?

In contrast to the tolerable risk framework, the safety management guide HS(G) 65, '*Successful Health and Safety Management'* (HSE, 1997) is an integral management system for risk management which incorporates the impact insignificant incidents/accidents may have on an organisation; demonstrating that insignificant accidents/incidents may have a more significant financial costing than less frequent, more severe accidents.

> *'Injuries and ill health cost money but are only one component of financial loss. Accidental damage to property, plant, products or the environment - as well as production losses or liabilities - also impose costs'* (HSE, 1997, p12).

To plan costing of accidents, which in turn provides an economic estimate, a risk triangle is used, figure 34, page 277. Validated by a study conducted by the HSE's Accident Prevention Advisory Unit (APAU) evaluating Bird (1974) risk/accident triangle.

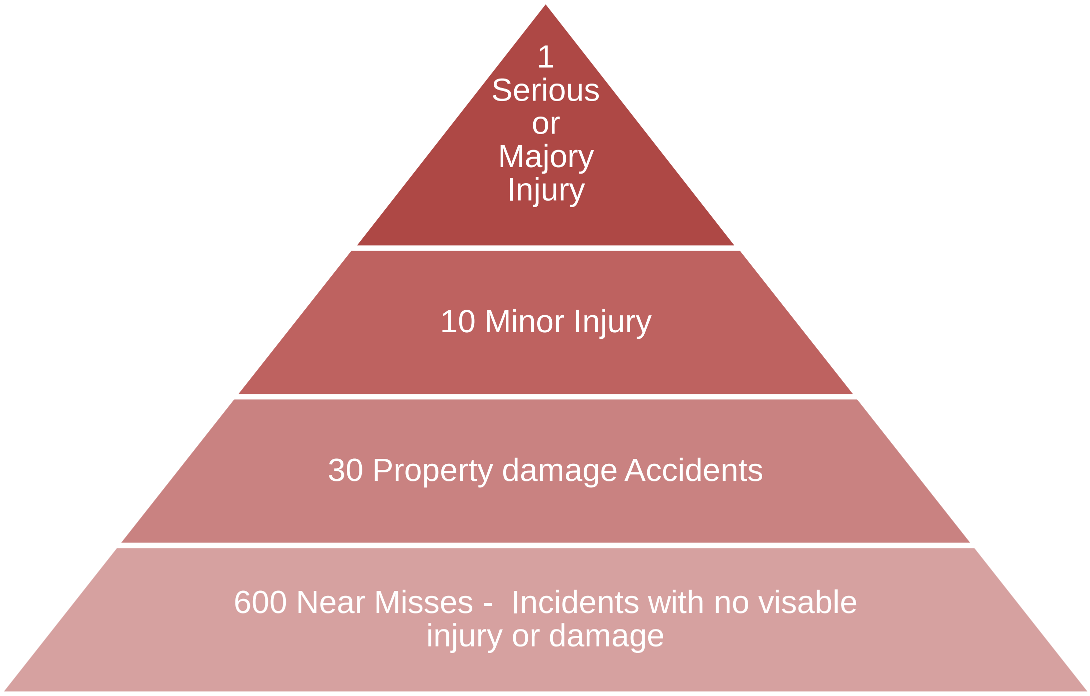

Figure 34: Interpretation of Bird (1974) Risk/Accident triangle.

An illustration of Bird's theory regarding accidents to near miss ratio.

Risk measures that are commonly used in quantitative risk assessment and risk management fail to address that minimal severity risk, does not mean minimum probability or magnitude of adverse health consequences. Therefore using this framework with social policies would skew unfavourably for IAQ, as risk involving a death from an accident, is clearer to calculate against a long term health condition, such as asthma. This implicates that mortality risk might often not be the most appropriate indicator of environmental risk. Using Bird's theory, I created a similar concept within figure 35 below.

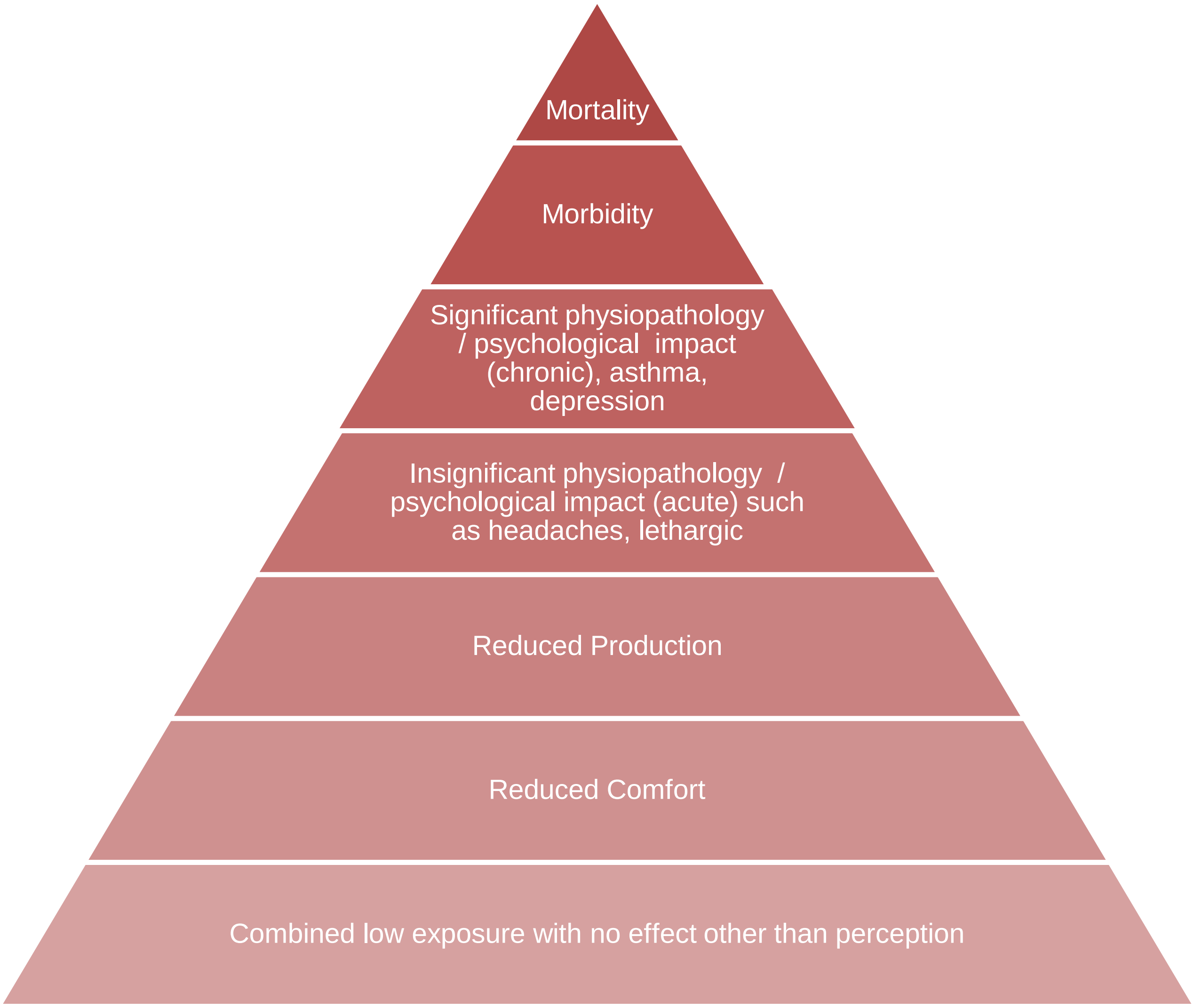

Figure 35: IAQ health impact triangle.

An interpretation of Bird's accident triangle using IAQ as the discussion topic.

Fischhoff, el at., (1981) claim that risk is never acceptable unconditionally, a risk is always counterbalanced, cost, benefits, returns, whether positive or negative.

> *'The option with the optimum mix of costs, benefits and risk is selected. The risk associated with the option is acceptable. All other options are unacceptable'* (Kaplan and Garrick, 1981, p24).

Therefore a cost model is required, as discussed within this chapter.

Accepting risks is a choice between how the risk affects people personally. In the case of IAQ, the trade-offs (such as latent health conditions) may be seen as acceptable when an individual gains a short term benefits (such as use of perfume).

No longer do we consider health as merely the absence of disease and infirmity (WHO 1948). An individual's capability to function well physically, mentally, as well as socially is the central issue in most papers on health status measurements (Froberg and Kane, 1989), (Goerdt et al., 1996). Public health focus has gradually changed from life expectancy to health expectancy, i.e. mitigating the risk of chronic disease (World Bank, 2003). The ability to cope with the demands of everyday life is a holistic view that cannot be measured by one event or loss (Committee on Medical Cure and Care, 1991). To engage further debate on risk, a cost model is required to stimulate an informed discussion within the risk tolerability framework, which I have included within this chapter. The complications of latent health effects, difficulties in demonstrating a linear relationship between an exposure and health/cost impact; the combined effects of indoor air quality creates difficulty in understanding the risk from body burden, as opposed to identifying a single contaminant.

Self-regulation

With a drive towards to self-regulation of workplaces, which has been reinforced by David Cameron's government, intervention in the form of regulatory legislation is unlikely and may not be necessary to address indoor air quality issues in the workplace. Cameron's self-regulation programme is not new and has been re-branded from Margaret Thatcher's government ideology of a free market economy that reduces the red tape and burden on business by deregulating legislation and encouraging self-regulation. During these discussions in the 1980s, the Government released several white papers on the burdens on business, *Lifting the Burden (*Home Office, 1985) and B*uilding Businesses - Not Barriers* (Home Office, 1986).

Although presented as consultation documents, the titles clearly indicated the direction of the Government. John Major reinforced this message upon his premiership in 1992 and in 1994 by creating the Deregulation Task Force; in 1995, the Government published *Deregulation - The Way Forward* (Heseltine, 1995) Labour, under Tony Blair's leadership, also pronounced war on red tape bureaucratic legislation, declaring business friendly policies. However, in contrast:

> '*Blair Government has broken all records by issuing 14,000 new regulations, and this year's figure looks set to be the highest yet' (Telegraph, 2001, p1).*

The debate continued and the government's views not to impose red tape legislation and to adopt a flexible self-imposed regulatory standard were prevalent in the Government's Deregulations Units to ease reforms (DTI, 2005). In November 2006, the first report from the Better Regulation Commission was published suggesting five principals of good regulations:

- *Proportionality – regulators should only intervene when necessary. Remedies should be appropriate to the risk posed and costs identified and minimised.*
- *Accountability – regulators must be able to justify decisions and be subject to public scrutiny.*
- *Consistency – government rules and standards must be joined up and implemented fairly.*
- *Transparency – regulators should be open and keep regulations simple and user-friendly.*
- *Targeting – regulation should be focused on the problem and minimise side effects.*

(BRC, 2006, p51).

The Task Force were almost entirely composed of members of national companies and were presented with the task of making recommendations on how existing legislation should be altered so as to relieve the burden on business. This included the review or relevance and usefulness of over 400 separate pieces of health and safety legislation. During this review the Government introduced the Deregulation and Contracting Out Act 1994 (HMSO, 1994) proposing powers for the Secretary of State for Employment to remove irrelevant legislation, effectively fast tracking deregulation. It is unclear though exactly what in the Government's opinion constituted a 'burden' and whether those burdens were superficial, perception or valid. The TUC had been a staunch opposition to the self-regulation approach, arguing that:

> *'Detailed examination of this may have shown that the "burdens" are perceived rather than real and that in practice they are far outweighed by burdens imposed on such businesses as a result of failure to manage health and safety effectively*' (TUC, 1993, p5).

The Final Report of the DTI's Deregulation Task Force was published in 1995 (DTI, 1995). Its proposals supported the reduction in health and safety legislation, perceived by many as a massive burden upon business, calling for a block on new EC health and safety legislation.

Similar considerations applied in the Victorian period in relation to balancing the occupational illnesses relating to lead, arsenic and phosphorus against competitive advantage of popular consumer goods. Herbert Brown of the matchmakers union felt the possible illness was a risk worth running for the reality of a job (Bartrip, 2003). Despite these views, industry and economics has continued to develop with a longest period of sustainable growth for 150 years (OECD, 2005). Safety legislation has contributed towards a more productive environment and has driven advancement in technology.

> ‘*Workplace absence and productivity are highly important issues. They affect our competitiveness and productivity as a player in the global economy. They can been seen as an indicator of how well an organisation is managed*’ (HSE 2006, p2).

Within the UK Government’s Strategy Unit Report (2002) ‘*Risk: Improving government’s capability to handle risk and uncertainty*’ Unilever, were used as an advocator of risk management, who linked risk taking directly to its ‘Path to Growth’ business strategy. Its risk management process has been positioned as fundamental to meeting its business goals. (Home Office, 2002).

Niall Fitzgerald, Chairman of Unilever, quoted:

> *‘Enterprise is about being prepared to go for it – it’s about having a real passion for what you are doing and wanting to win. It’s about being courageous and taking risks. Accepting that when you take risks you can make mistakes, but that these can provide a rich learning opportunity’.* (Home Office, 2002, p96).

Unilever used such competitive advantage in less regulated countries, such as the use of child labourers within their hybrid cottonseed production in India. The report by the India Committee of the Netherlands notes that local seed farmers secure the bonded labour of young girls by offering loans to their parents in advance of cultivation (Venkateswarlu, 2003).

There is a counter argument to be made that such overly avertedly regularities will lose competitive advantages, but the economics of paying a bonded labourer a handful of rupees to work long hours in hazardous conditions does not equate to a fair, balanced and reasonable argument.

Deregulation and self-regulations carry similar debates with regards to advantages of being more flexible to meet the changes in industry, specific industry bodies creating standards and a cost effective method for controlling risk. IOSH have welcomed such reforms with a clear objective:

> *'Caution should be exercised to avoid over-reliance on self-management. For example, in our evidence to the Löfstedt review we highlighted a study in which the use of third-party certification and testing schemes as an alternative to traditional regulatory arrangements' (IOSH, 2011, p2).*

A clear message that third party organisations should be instrumental and effective in managing risk within their industry, with an unambiguous note of caution:

> *'although this approach may appear politically attractive as an alternative to legislation, underestimation of the critical issues in the functioning of certification and testing schemes is likely to hamper effectiveness' (IOSH, 2011, p2)*

Dissimilarly self-regulation can lead to confusion regarding standards and small businesses may not necessary have access to the same resources for compliance as a large organisation that can subscribe to expert support, it also creates an environment whereby companies can abuse the system with no fear of losses from lack of compliance.

The driving force of compliance has arrived in the format of insurance claims and despite its critics it has created a motivation for employers to comply with health and safety (HSE, 2005b). Although I would consider such litigious activities as a perception as there is little evidence to demonstrate we have an actual litigation culture in the UK (HSE, 2007b).

Although litigation within America has raised the agenda with the first IAQ case Call v Prudential in 1990 (Phillips and Snowden, 2005) whereby the plaintiffs claimed that the defendants were negligent in using building materials capable of emitting formaldehyde, a known toxin, failing to warn tenants the building was not yet suitable for occupancy, failing to provide adequate ventilation, and failing to prevent the occurrence of airborne chemicals causing polluted air. While the plaintiffs focused their attack primarily on the building owner, the judge in Call v Prudential extended the chain of liability for the indoor air quality problems to everyone who was involved in the heating, ventilation and air conditioning (HVAC) system. The litigation resulted in a multi-million dollar settlement. Similar cases have also been seen in Australia, Bishop v Commonwealth of Australia in 1982 (Department of Health and Aged Care, 2000). To mitigate the risks, several US firms are offering ‘pollution legal liability select’ insurance cover to reduce liability associated with indoor environmental risks. Despite the compensation culture perception, in the UK since the introduction of the Civil Claims Protocols in 1996 by Lord Wolfe, there has been a gradual 5% reduction in tort claims (Lewis et al., 2006), thus dismissing this channel as a motivational factor for compliance.

Instead, developing the social-economic agenda may influence organisations in initiatives to incorporate indoor air quality concerns into their places of work. By providing educational and technical assistance, and developing policy options directed at employers, particularly with regards to ethical issues surrounding indoor air quality; including ownership of responsibility and the social-economical returns from investment which correlates with the drive with localised, sensible risk management decisions.

Currently indoor air quality is considered acceptable if the ventilation rates are compliant with the building regulations. The disadvantage of this criteria is it fails to discuss contaminants, comfort, odour nuisances and the insufficiency of building rates when compared to activities within the space, number of occupants and layout of the indoor environment.

There is also a growing debate regarding how we work, such as those who work from home, an aging working population and a long working hours society, who are also subjected to the same social-economic concerns and highlights some of the social agenda health topics related to IAQ.

Therefore, the demand for a more comprehensive procedure or guideline addressing indoor air quality issues in the workplace is becoming an increased reality. Engagement and cost effective management will be the key indicator requiring further exploration as a compliance tool for self–regulation of IAQ management.

6.3 What is the advantage of creating a cost effective model to estimate IAQ management benefits?

To implement self-regulation of IAQ management, an effective business case and costing model to demonstrate the benefits is required. Such modelling will contribute towards the knowledge and understanding of IAQ and the rationale for management.

Developing a cost effectiveness model to demonstrate the direct financial rationale for managing indoor air quality is complex, due to the latent and/or attributing causes of ill health, production/performance losses. Currently only initial costs and energy and maintenance costs are associated with building design and operation, failing to discuss the economic calculations pertaining to the occupants.

The correlation between economic and social impact of IAQ is evolving. Many of the model calculations show that the cost of deteriorated indoor environments via case studies. Such studies calculations have shown that many measures taken to improve indoor air quality can be cost-effective, such as reduction in sickness, absence and performance, which can serve as a strong stimulus for energy efficiency measures that simultaneously improve the indoor environment.

However these studies are silo, Seppanene and Fisk (2005) addressed this concern with a conceptual model to estimate the cost-effectiveness of indoor environments. The model shows the links between the improvements in the indoor environment and potential benefits. They have quantified the links between ventilation and absence and high temperature and productivity.

Seppanen and Fisk (2005) have demonstrated substantial evidence between the correlations of IAQ and cost effectiveness, however the quantitative relationship between these variables of building feature, ventilation, occupant activity, building furnishing, health, comfort and productivity will consistently vary and additional dynamics, such as the weather and maintenance increases these permutations.

Therefore a concise model can only be estimated, which presents challenges in addressing national and localised policy and resource decisions.

As an initial step towards systemising these building level calculations, a conceptual model to estimate the cost-effectiveness of various measures shows the links between the improvements in the indoor environment and the following potential financial benefits. However Seppanen and Fisk (2005) recognised the limitation and concluded that:

> *'Even though the cost-benefit model presented in this document is largely conceptual, we consider it a useful framework for the incorporation of productivity in cost-benefit comparisons of building designs and operating practices'* (*Seppanen and Fisk, 2005, p10).*

Nevertheless the conceptual model illustrates how various factors are linked to each other and provides an encouraging step towards an interdisciplinary approach.

A considerable degree of uncertainty is associated with incorporating health and productivity within cost benefit analysis related to building design and operation. While the available evidence indicates that symptoms associated with poor indoor air quality can affect occupants, there is no data to quantify the relationships sufficiently for direct cost-benefit modelling.

I would question whether a model is possible for new building design, as caution would be applied to relying on a model whereby the activities/occupants have not be considered within the assessment, thus increasing potential susceptibility to contaminants. However, the design aspect of a building can impact the risk of indoor air quality, particularly with regard to suitable ventilation rate capacity, building materials used, space planning.

New research and analysis of existing data to quantify the financial importance of indoor air quality would enable more widespread consideration of the effects in cost benefit calculations. In particular, the US Environmental Protection Agency (US EPA, 2009) has reviewed the environmental and health impact of building holistically and has included indoor air quality. However this data is unable to provide a direct lineage between health and the indoor climate. Figures presenting asthma and cancer do not consider other trigger factors.

As a concluding thought, energy efficiency, which couples financial savings, does not have to be an opposing factor to good indoor air quality, and that a balance can be achieved with discussions between key stakeholders from building design, maintenance of HVAC systems and building management teams.

6.4 Body Burden – What do we understand about the impact of IAQ as a contributor to our existing body burden?

Onstot et al., (1987) estimate that an individual carries a body burden of approximately 700 contaminants. Because many chemicals have the ability to attach to dust particles and/or catch air and water currents and travel far from where they are produced or used, the globe is bathed in a chemical soup. Our bodies have no alternative but to absorb these chemicals and sometimes store them for long periods of time. Due to the latent affects and the uncertainty of the effects of the combination of substances, body burden indicators are often difficult to extrapolate quantitative risks; which challenges our traditional view of the scientist report of cause and effect.

Historically, science has often focused on one common denominator as a cause and effect, which influences public health regulations and theoretical risk calculations according to known levels of chemical substances in the air, such as the EH40 (HSE, 2005). Exposure to environmental pollution may lead to a certain body burden. Air masses always contain many pollutants in differing amounts, depending on the types of source and atmospheric conditions, therefore occupants are simultaneously exposed to a complex mixture of air pollutants. Thus multi-pollutant assessment approaches are desirable, but challenging.

The multi-pollutant assessment may give an impression of integrated exposure via various routes over a certain period of time. The EC introduced bio-monitoring (COM, 2004) to explore the impact of interaction between environment and health. Human bio-monitoring offers the opportunity to analyse the actual internal levels of bodily substances from all potential routes of exposure at one time, which may contribute to improving risk assessments. However, knowledge of the toxic kinetic properties for a meaningful interpretation of most biomarker results are sparse.

In support of the European Environment and Health Action Plan 2004-2010, European scientists and stakeholders from 35 institutions in 27 European countries formed a consortium to perform human bio-monitoring on a European scale. COPHES (Consortium to Perform Human Bio-monitoring on a European Scale) is funded by the European Community's Seventh Framework Programme (FP7/2007-2013). This project has stalled and was eventually started on 9th December 2009, with an expected 3 year lifespan. The Health Protection Agency and the Department of Health have acted as the lead in undertaking a scoping study of current and planned Human Bio-monitoring projects in the UK. The information was intended to feed in to the inventory of bio-monitoring activities being gathered across the EU as part of Action 3 of the European Environment & Health Action Plan 2004 – 2010 to develop a coherent approach to Human Bio-monitoring in Europe. This study's objective was to enable the UK to monitor its Human Bio-monitoring projects and develop a more co-ordinated approach. In addition to body burden calculations, there were extensive variables, such as lifestyle choices, geographical location near sources of contaminations, pre-existing health conditions and susceptibility to risk. As of October 2012, no data regarding the UK's Health Protection Agency has been released to the public domain. There is no evidence of bio-monitoring activities taking place. During the writing of this project I contacted the Agency twice requesting an update on the action plan; no response has been received to date. Irrefutably the air we breathe is a contributor to the existing chemicals and substances we eat, drink and absorb into our skin. The quality of indoor air and the impact on our body burden may be considered a minor contributor to the health burdens of the UK. Nevertheless, despite our knowledge of single contaminant studies, we have yet to identify the full scope of outcomes of exposure to poor IAQ and the relationship of sub-clinical, physiological, psychological and performance factors. Without bio-monitoring and multi-pollutant frameworks we can only speculate on the effects of the body burden impact which enervates any sensible discussion of risk and well-being of the individual.

6.5 Scent marketing – Is the growing trend of scent marketing and ambiguous labelling the sleeping giant of the future?

The Environmental Health Practitioners' survey provided an interesting account of odours and perfumes. Question 3 asked which indoor air contaminants appear to present the greatest health risks?, with only 17 standard mean responses indicating perfumes/odours and 62.4 standard mean indicated benzene; despite the reality that perfume contains benzene, which may indicate a lack of knowledge of ingredients in perfumes. Question 10 provided a list of potential contaminants and requested information on highest complaints per contaminants, indicating temperature (43.4) and odours/perfume (42.8) being the most significant. As we look to the horizon, the use of scents, particularly within marketing, is becoming more evident and therefore the risk of complaints may also increase.

The future

The sense of smell is often subtlety used as a way of marketing products. Research focusing on the experiential qualities of autobiographical memories suggests that memories evoked by olfactory information are more emotional than memories associated to cues perceived through other modalities (Herz, 2004) (Herz and Cupchik, 1995) (Herz & Engen, 1996). Therefore the use of sense as a marketing brand in an over saturated visual and audio environment drives a competitive advantage.

The new car smell as discussed in chapter 2, page 67, is the smell of a number of harmful chemicals, including antimony, bromine, chlorine and lead. Repeated and concentrated exposure to any of these chemicals may contribute to a variety of acute and long-term health issues such as birth defects, impaired learning, liver toxicity and cancer (Shea, 1972).

The first smelling mobile phones were introduced into the market in 2008. The Sony Ericsson SO701i is scented with eight different aroma therapy fragrances to support relaxation during stressful phone calls. It is anticipated that the scents will be used for advertising purposes and tagging personal items, such as mobile phones with corporate scents. It is currently only available in Japan (USPTO, 2010a). The Hyundai MP280 integrates an individual refillable scent diffuser which acts as a smelling tone. Samsung and Motorola also hold patents for smell phones USPTO (2010b). Within Europe German inventors have already patented a mobile phone with a smell chip which allows sending and receiving smell messages (Sarjanoja et al., 2009). These mobile devices could be the future of mobile advertising; they are offering a new method to send not only informative but also emotional advertising messages via senses.

Canada and the US have recognised the impact of scents within an enclosed environment. Canadian safety authorities have been driving a '*no scent, make sense'* campaign (CCOHS, 2010), as discussed on page 296. Multiple Chemical Sensitivity/Environmental Illness (MSC/EI) is recognised as a disability by The Social Security Administration in the US, therefore the American Disabilities Act 1992 (ADA) state buildings must be reasonably accessible to disabled persons and views fragrance as a barrier to access to MCS/EI disabled. The US state postal regulations prevent fragrance samples offered within printed media or the perfume must be enclosed in a sealant sufficient to protect a consumer from inadvertent exposure and cannot be activated except by opening a glued flap or binder or by removing an overlying ply of paper (FR, 2011).

Scents have been used for positive influences, such as technicians at New York City's Sloan-Kettering Cancer Center disperse vanilla-scented oil into the air to help patients cope with the claustrophobic effects of MRI testing. Scents are used at the Chicago Board of Trade to lower the decibel level on the trading floor (Miller, 2011).

Many of the same chemicals in perfumes are the same chemicals that are in cigarette smoke, such as benzene, formaldehyde and toluene (Derudi, et al., 2012; Smith, 2007) Second-hand smoke contains more than 4,000 chemicals, including at least 69 carcinogens and there is no established standard for safe level of exposure to many of these chemicals (Smith, 2007). The Institute of Medicine placed fragrance in the same category as second-hand smoke in triggering asthma in adults and school age children (IOM, 2000). The issue of fragrance may be as controversial as today's tobacco smoke issue. The debate over people's right to smoke versus others' right to breathe clean air could also be applied to fragrances. We have recently changed the law relating to the responsiveness to the hazards of tobacco smoking which were known for many years prior to being made public. This creates an interesting paradox, that unpleasant smells such as smoke and paint fumes are unacceptable and Government and pressure groups have changed legislation/practices, however the use of perfumes and scent marketing is growing at an alarmed rate, unregulated, using unlabelled ingredients and mixtures that suspend the aromas in the air much longer.

Labelling

The most prudent method of avoiding health risks from internal sources is to ensure that there are no toxic or potentially toxic materials brought into the building or used as part of the construction of the building, following a priority selection of eliminating IAQ hazards at source, rather than controlling and monitoring the hazard in situ. Many of the contributing factors of indoor air contaminant sources are from the products and materials used within enclosed buildings. In particular, VOCs from primary products such as accelerators, additives, antioxidants, monomers, plasticizers, solvents and unreacted raw materials as well as secondary emissions, such as decomposition of material surfaces like linoleum (Wolkoff, 1995).

The availability of low emitting products is varied throughout Europe. For example in Finland there are some 1,200 products labelled according to the Finnish 'M1' scheme, a voluntary emission classification of building materials; whereas in the UK there is no recognised national scheme. However in the UK some companies participate in industry based schemes, such as the German GUT label for textile flooring coverings, recognisable by the label on the backing of the floor product. Eco-labels can be found on paint products indicating low or no VOCs and include the European Eco-Label, regulated by DEFRA in the UK, Blue Angel in Germany, and Green Seal and Greenguard in the USA. In the UK, VOCs are labelled indicating the content using one of five classifications: Minimal (0-0.29%), Low, Medium, High and Very High (VOC content greater than 50%).

In 2007, the Department of Communities and Local Government developed a Code for Sustainable Homes (DCLG, 2010). Despite research recommending an IAQ management plan of low emission products being used and testing of the building prior to completion, the recommendations were excluded from the Code without explanation; therefore failing to balance the needs of sustainable living and the health impact of the occupants.

One important aspect of building product emissions is the link between VOC concentrations and perceived air quality as both can impact health, comfort and productivity.

The Danish Indoor Climate Labelling scheme recommends requirements to both the concentration of selected VOCs and a sensory assessment of the emissions (perceived odour intensity). The recommendation to include perceived odour establishes a pragmatic safety factor to account for the possibility of contributions of the same VOCs from other pollution sources with less odour thresholds.

An understanding of this interrelation is essential for the ability to predict the possible impact of emitted VOCs on these aspects of indoor air quality. Such information is very useful for developing better building products with a low emission and a low impact on the perceived air quality. However the schemes have evolved independently and therefore details differ and this can be quite confusing for persons selecting products. For example, some schemes include sensory testing (by a human odour panel) as well as measurement of the amount of chemicals. In recognition of this issue an expert group supported by the European Commission are working towards harmonisation of core requirements of labelling schemes.

A number of companies have information about their products, including construction products being developed under the Construction Products Directive (CPD) however such labelling is not obligatory in all countries, to allow them to access markets where emission data is required by clients. Until a European/Global convergence of methods of assessment, testing and labelling is achieved, drive for increasing low emission products will be driven by application of the manufacturer within voluntary schemes and the approval of the consumer.

The barrier to encouraging the development of such schemes is the cost effectiveness, the positive effects of improvement of the indoor environment by the use of low-emitting building materials, i.e. fewer complaints, is difficult to document (Tuomainen et al., 2001).

Scent Free Workplaces

Fragrances are complex mixtures of volatile organic compounds (VOCs), formulated to have a specific odour. Once in the air they break down, mix with other pollutants, and form new compounds that are often more irritating or allergenic than the original substance. VOCs are associated with exacerbating respiratory disease, such as asthma, respiratory irritants and lung inflammation (Bridge, 2002).

A recent analysis of 6 top selling laundry products and air fresheners found nearly 100 volatile organic compounds (VOCs) were emitted from the products and five of the six products emitted one or more carcinogenic hazardous air pollutants which the Environmental Protection Agency (EPA) considers to have no safe exposure level (Steineman, 2008).

The Scientific Committee on Cosmetic Products and Non-Food Products (SCCNFP) in Europe has recommended that known skin sensitizers be listed on the label to allow consumers to avoid products that contain known allergens, however respiratory concerns have not been addressed. The Cosmetic, Toiletry, and Fragrance Association (CTFA) in the US assess the safety of cosmetics, but again only focused on dermatology, there are no details regarding inhalation.

The self-regulation of the perfume and cosmetic industry creates challenges to identify substances of concern and assess within a clinical/scientific environment. A cooperative approach from the industry, regulatory agencies and the scientific community to establish a system for identifying, evaluating and monitoring potential adverse health effects from such products, to enable development work of less harmful substances is preferred to ensure a sensible, balanced risk approach.

The demands for a fragrance-free workplace are following the same trajectory as the second-hand smoke discussions (Salvador, 2009) (Singer, 2008). Most of the organisations that have implemented fragrance-free workplaces initiated the response to either a negative incident (e.g. a sick building) or because of an employee’s complaint (Environmental Health Network, 2002) (Health Care Without Harm, 2006) which reflects the findings within the local authorities survey.

The movement against fragrance is in its infancy, with Queen Elizabeth II Health Sciences Center in Canada as the first to enact a scent-free workplace policy in 1991. (CCOHS, 2007) (Environmental Health Network, 2002). Progress to develop this awareness may take as many years as the passive smoking movement did to gain momentum. Within the US and Canada, a correlation between second-hand smoke and perfume has been seen within the courts (McBride v The City of Detroit, 2007) which has broadened an appreciation of the concern. Smokers exposed themselves to adverse health outcomes from smoking and exposed bystanders to the adverse health outcomes of second-hand smoke. Occupants who use synthetic fragrances in their daily personal care products contribute their own personal contaminants that the general public breathes. Unlike tobacco products, some fragrance products are designed to be slow release so that the fragrance dissipates over an extended period of time (Bird, 2008) (Rosen, 2005) thereby extending the length of exposure.

Implementing a no-fragrance policy can become a challenge because it is such a personal issue, and many employers may be reluctant to go that far. It is also very difficult to enforce. However, through worker education and the implementation of an effective scent-free workplace policy and alternative control strategies, the impact of this hazard can be greatly reduced or eliminated altogether.

De Vader (2010) recommends an eight step strategy in developing an effective fragrance policy from identifying employee's needs, reviewing of all existing chemical products used, conducting a literature search; as De Vader validates using current information, as data regarding chemicals are evolving constantly; development of a scent free policy, implement the policy with executive support, develop disciplinary procedures to ensure the policy will be enforced, communicate the policy to outsiders such as customers, contractors and members of the public and finally evaluate the effectiveness of the policy.

In a climate that has become increasingly sensitive to over-regulating society, a consultation offers a valuable opportunity to begin educating employees about chemical exposure due to scents (Wolff, 2005). Feedback from employees is also useful for identifying points of employee buy-in and resistance to change.

6.6 Influencing change – What parallel lessons can be drawn from understanding societal concerns of risk and influence change?

There is a gap between publishing knowledge, the reader's understanding and acceptance of the knowledge and the reader's reaction to instigate a behavioural change from the knowledge. This is demonstrated within the smoking agenda, whereby there is no lack of understanding indicating a relationship between smoking and health concerns, or visibility, the harm displayed on cigarette packets or health campaign material; yet despite such overwhelming evidence, people still decide to start smoking and continue, even when faced with the outcome of a health concern. Therefore when faced with a risk that has a pleasant smell, perhaps even associated with fresh aromas, the challenge escalates.

Societal concern is a relatively new term and refers to hazards with the capability to generate socio-political responses. Hazards invoking societal concerns pose a challenge to policy makers, particularly when a perceived risk may outweigh the actual risk. Failure of policy makers to respond may result in a loss of confidence by society in the provisions and arrangements in place for protecting people.

A perplexing element of risk analysis is why some relatively minor risks or risk events, as assessed by technical experts, often elicit strong public concerns and result in substantial impacts upon society and economy while others have minimal effect:

> *'Understanding this phenomenon is a prerequisite essential for assessing the potential impacts of projects and technologies, for establishing priorities in risk management, and for setting health and environmental standards'* (Kasperson et al., 1988, p187).

Often societal concerns are associated with controlling amplified risk within the public arena, conversely this can also impact where a lack of societal risk perception can abate policy makers to control actual risk.

Upon completion of this project, I intend to continue my passion to raise the perception, knowledge and understanding of IAQ and therefore it is not sufficient to merely understand and communicate the risk. Understanding the drivers and motivation and how to create a societal concern, with an ethical application, will assist in creating a push effect from the public to demand change. The latent effects of IAQ and the perceived low risk will create challenges. Considering a comparable, I explore the history of asbestos, a known carcinogenic, I am interested by the delay to regulate the hazard, society's perception and the conflicting messages of control that are given today.

The Chief Inspector of Factories reported as early as 1898 that asbestos had easily demonstrated health risks, with the first documented death related to asbestos in 1906. In the early 1900's researchers began to notice a large number of early deaths and lung problems in asbestos mining towns. The first diagnosis of asbestosis was made in the UK in 1924. By the 1930's, the UK regulated ventilation and made asbestosis an excusable work related disease. The term mesothelioma was first used in medical literature in 1931; around 1945 where most physicians agreed that long-term exposure led not only to illnesses such as asbestosis, but to certain kinds of cancer (Tweedale, 2001).

Yet, when we review the legislation regarding the risk, the control was slow and people working with the materials were uneducated and indifferent to the risk.

Table 32: History of asbestos legislation.

An outline of the UK's asbestos legislation.

1830s	Asbestos use in UK becomes common.
1972	Voluntary ban on use of Crocidolite.
1983	Asbestos (Licensing) Regulations introduced aiming to introduce strict guidance on how asbestos should be removed.
1985	Asbestos (Prohibitions) Regulations introduced a ban on Crocidolite (Blue asbestos) and Amosite (Brown asbestos).
1987	Control of Asbestos at Work regulations introduced to protect workers from fibre exposure when working with asbestos containing materials.
1992	Asbestos (Prohibitions) Regulations amended to include ban on rarer forms of Amphibole asbestos (Tremolite, Actinolite and Anthophylite).
1999	Asbestos (Prohibitions) Regulations amended to include ban on Chrysotile banned.
2002	Control of Asbestos at Work Regulations 2002 introduces regulation 4 where businesses are obliged to identify and manage asbestos in their properties.
2006	Control of Asbestos Regulations 2006 introduced. This is an amalgamation of previous asbestos legislations.
2012	The Control of Asbestos Regulations 2012 came into force on the 6th April 2012, updating previous asbestos regulations to take account of the European Commission's view that the UK had not fully implemented the EU Directive on exposure to asbestos (Directive 2009/148/EC).

Alarmingly in 2008, 4498 deaths were attributed to asbestos (HSE, 2010a), the TUC expect this to rise to 10,000 deaths by 2015 (TUC 2011) compared to an annual average of 180 workplace deaths (HSE, 2010b) or 2,222 road deaths (Department for Transport 2011). Despite these shocking figures asbestos is still not effectively managed, with a view that certain types of asbestos, such as cement asbestos (Artex, 'Marley tiles' and corrugated cement sheet) are considered safe. (HSE, 2007). This view is not shared by many authors (Dyczek, 2006),(Fikfak et al., 2007), (Campopiano et al., 2009).

Asbestos cement roofing sheets are exposed to the elements once they are put in the roof, so they are subject to deterioration from installation, which leads to a disaggregation of asbestos cement from weather elements (Haga et al., *2005),* rain (Dias et al 2008), moss and lichen (Turci et al., *2007*).

> '*The deterioration becoming the most widespread sources of airborne toxic asbestos fibres. This takes place in variable quantities, depending on exposure to atmospheric agents and on fractures due to indirect (vibrations, etc.) or direct (maintenance interventions, demolition, or acts of vandalism) mechanical action'* (Campopiano et al., 2009, p627).

The impact of regulating cement asbestos would carry huge societal risks; cement asbestos is commonly used within domestic houses, garages etc, so the impact of people responding to regulatory controls may increase the exposure risk by individuals trying to remove the material. This also raised the question of how to dispose/process appropriately. Therefore one might argue the Government are tolerating the risk, until the amount of cement asbestos is naturally removed and replaced by more appropriate materials. A similar debate regarding medium-density fibreboard or MDF draws parallel discussions (Priha et al., 2010).

The European Commission have recently criticised the UK for failing to transpose correctly the EU Asbestos Directive by omitting activities that involve only sporadic and low-intensity exposure to asbestos, as an example, in the case of some maintenance and repair activities (SHP, 2011). Only 10 'in court' news articles relating to asbestos within the Safety & Health Practitioner (SHP) magazine during 2010 and 11 recorded prosecutions on the HSE prosecution database for the same period. With exposure still occurring, a recent case included large retailer Topshop who exposed 45 workers to asbestos during a refurbishment project (Liverpool Echo, 2011), one might assume that increasing risk perception may change cultures. However, Stewart-Taylor and Cherries (1998) hypothesised that increased risk perceptions of asbestos of workers would lower exposures and hence lesser risk, conversely they were unable to demonstrate any direct link between risk perception and asbestos exposure. The HSE (2007a), explore a range of issues that may affect an individual's behaviour of safety around asbestos and concluded on four main categories:

1. *Technical issues relating to the complexity of messages about asbestos, its effects and how to deal with it effectively;*
2. *Psychological issues, concerning an individual's attitudes towards risk, health and the specific risks posed by asbestos;*
3. *Cultural factors such as pressures from their employers, clients, co-workers etc, which are largely driven by economic as well as social pressures;*
4. *Control factors, namely the extent to which individuals feel that they are able to control their work environment. These are linked to the nature of the employment contract an individual has, and their labour market capital.*

(HSE, 2007a, p10).

Clearly the employer has a powerful influence, whether positive or negative, with regards to the attitudes towards risk within a work environment, although the HSE has failed to include social influences. Li et al., (1983) noted that risk perception appeared to have little influence on US asbestos workers decisions to stop smoking, with 'saving money' and 'smelling better' as the two most important determinants. Others have noted negative association between workers who are better informed about the risks, such as solar UV radiation, are less likely to protect themselves (Modan and Aziz, 1988).

Indoor air quality problems are almost exclusively approached reactively rather than proactively, from a risk avoidance viewpoint. Efforts are directed at mitigating problems as they arise rather than trying to prevent them in the first place. While the development of a formal IAQ management framework is presently lacking in the non-industrial workplace, support is continually growing for indoor air quality issues, in terms of research and management practices. Addressing all IAQ issues through the implementation of an indoor air quality management programme, policy or guideline is considered to be the optimum approach to dealing with indoor air quality. Despite the interest, this approach has stalled and failed, with limited resources or action, despite the silo information demonstrating the importance.

Within Healthier Schools (Environmental Law Institute, 2002), they discuss the public rights to know about indoor air quality within schools, by publishing results of school's IAQ programme, thus making the schools responsible. This has been a strategy adopted by the HSE and local authorities in publishing companies that do not conform to health and safety legislation, such visibility allow peers to judge performance in the form of client/contractor interactions, (pre-tendering information). The prospect of a IAQ healthy building certificate (similar to the Energy Performance Certificates) may raise the interest and agenda.

Exploring the permutations of how we might influence provides challenges for a hazard that has low to negligible risk perception in the workplace, Government policy makers and the media.

Research has found that people are unaware and seemingly apathetic of the issues related to indoor air quality (Morgan, 1993) (Harrison, 2002). This has been endorsed by my own experiences during my DProf journey, however when discussing the link between perfumes and air fresheners or scent marketing, there appears to be a greater interest and relationship with the subject matter. This promulgates an opportunity to explore a personal relationship with consumers in the workplace.

Individual choices are powerful, looking at the organic movement, whereby individuals made a choice about body burden via ingestion. Organic food sales increased from just over £100 million in 1993/94 to £1.21 billion in 2004 (an 11% increase on 2003 (Organic Centre Wales, 2009).

To drive culture change, the transformation requires more than just actual risk, cost effectiveness or indeed perception of risk, it has to relate, create an emotional relationship with the audience. Upon this reflection I would wish to explore the relationship of influence with society to understand how to create a personal relationship of IAQ, prompting behavioural change, particularly with regards to consumer purchase power and understand drivers for employers to implement change in the workplace.

6.7 Reflecting on the effectiveness and limitations of my project

Within my literature review I have used a broad range of resources to explore IAQ within both a scholar and real world application. The literature review enabled me to understand the history and context of IAQ with the intention of applying knowledge in a real world application. Rossi et al. (2004) define the methodological programme theory as a:

> '*Plan of operation, the logic that connects its activities to the intended outcomes, and the rationale for why it does what it does*' (Rossi et al. 2004, p44).

As previously discussed, my project plan, the boundaries and direction of this project has continually changed, with the objective of addressing salient learning points, as part of my action learning, ensuring the success of my project. Despite my initial difficulties in structuring my project, by immersing into the project, and using tools such as action research, reflection and active learning, I was able to navigate my quagmire effectively.

As a reflective point, the scale of IAQ, the broad stakeholders, the complexities of disciplines and competencies and the interaction between the triple helix model resulted in a condensed version of my initial objectives. My intention was to write one training programme, however the competencies and required knowledge for the indented stakeholders of transdisciplinary practitioners, HVAC technicians and occupational hygienists would be too broad to cover within my programme. Therefore I decided to reduce the scope of the training by creating an awareness course aimed at the OHS community.

It is consequently my intention to explore a series of courses aimed at target delegates, working in consultation with the relevant governing bodies/organisations, such as REHVA, CIBSE, BOHS, etc.

The holistic nature of defining my project and the application of tackling multifarious issues is succinctly described by Cohen and Manion (1994) who delineate action research and the application of triangulation as:

> *'An attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint'* (Cohen and Manion, 1994, p233).

Due to the absence of current writing around IAQ, the silo topical approach and the deficiency of real world application, I used global and UK resources, from academic papers to Government reports to provide a multi-dimensional view. Providing a document with depth I considered a triple helix approach, multi-layering and real world application. The results from the literature view and survey provided more questions that required a discussion, which I felt had inclusion value within this chapter.

The surveys generated no new knowledge and provided justification to the results from my literature view regarding perception of IAQ. Although, in retrospect, I would have also considered the application of using Fanger's (1988) model of olf and decipol units for exploring perception of occupants for future studies, understanding what people term as freshness, good or bad air. The OHS practitioner's surveys provided limited useful data that could have assisted with implementing a strategy of IAQ. The EHP's survey provided a key epiphany that IAQ has limited visibility, despite it being an active subject within their complaints. The reinforced view regarding the lack of knowledge of IAQ and the interest of perfumes/scents highlighted the importance of creating society concern model that focused on developing individual's personal connection with IAQ. Had I introduced further project activities into the study, I would have been interested to explore the public perception of IAQ and their relationship with risk, as society concerns seem to be the biggest driver to cultivate change.

I would like to focus on perfume and understand public views as this could impact uptake of interest from certain sections of society that are already conscious of chemical impacts, such as the organic movement, environmentalists.

The website and training have been a success, with good web site traffic and feedback on the training programme. The project activities are a permanent outcome from this project and will continue to evolve and develop as I continue to understand the interests of readers/delegates.

As a criticism, I have neglected to consult with a much broader community on IAQ, particularly stakeholders discussed in table 2, page 28. However following positive feedback from the UKIEG conference, the verbal confirmation from fellow peers will stimulate my understanding that this paper has value for an establish IAQ community and will offer a unique contribution to IAQ.

Throughout this project, I have contemplated whether IAQ should be incorporated into established bodies, such as the UKIEG, IEH, CIBSE, IBL; however I feel that IAQ is an important agenda and requires a distinctive voice, particularly when balancing debate regarding building design, product development and the cost association with comfort, productivity and perception of IAQ. It is my intention to build bridges with such bodies to assist with raising the agenda of IAQUK, working collaboratively in achieving this vision.

A constraint I found within my research was timeframe, as I felt I have many further avenues to explore following my literature review and surveys, this will form part of my research activities outside of this doctorate programme.

This project has enabled me to explore and understand drivers and identify gaps in the current knowledge that will allow for effective management (body burden, cost modelling). This project provided a snapshot of one period in time and exploration of a concept which impacts on organisations, government and practitioners and provides further stimulation to explore influence perceptions and practice.

In addition to the literature review and project activities, there were two sources that contributed towards action research:

- Application of active learning;
- Reflection of role as a researcher.

Application of Active Learning

The methodology used in the first cycle of action research was the application of learning, which links theory with practice through an iterative process of problem diagnosis, action intervention and reflective learning. The need to enhance knowledge transfer has been continuously articulated throughout my project, identifying gaps in multi-discipline silo organisations and transferring competencies into changes within research and practice. Therefore within my schematic of my project plan, I have included a framework for active learning to ensure problem-solving process and extraction of lessons were included to new knowledge through reflections and experience which is considered as an organic process throughout the project. Allen (2001) describes action research as an:

> '*Intervention-based approach where the focus is action to improve a situation and the research is the conscious effort, as part of the process, to formulate public knowledge that adds to theories of action that promote or inhibit learning in behavioural systems'* (Allen, 2001, p1).

Slavin (1997) discusses the active learning process as a contributor to a self-awareness of your learning process which incorporates new knowledge and experience. Reflection has been a continuous companion throughout my DProf programme and therefore the application of active learning with my action research model was essential. Modelling an active learning structure presents complexities, in that the open-ended nature of problem solving and active learning is a natural process that has variable dependency on my current knowledge and experience and the intensity of learning would adapt throughout the project. Therefore integrating a journal and reflective time throughout this project has enabled a structure to my learning within the methodology. Active learning has enabled me to develop a lifelong learning appetite and skills that equipment me for the journey of challenging new problems and situations on the horizon.

Reflection of role as a researcher

Aside from quantitative and qualitative findings, my continuous reflection throughout the project adds value to the overall action research outcome and requires integrating into the findings. Diary developments and self-learning was employed as a method of reflection and a critical appraisal of the project. Reflection has been included as a key component within the timetable to ensure a critical evaluation of my work, methodology and interpretation of findings. Reflection of the research was based upon the achievement of defined objectives and whether the adherence to the scheduled timetable, methodology, quality of data collection, the interest from relevant bodies and the influence the research had intended to impact. Diary entrances also enabled me to explore the dynamics of IAQ within social context, reading and discussions. The reflection of my motivation for writing was explored through my diary. Mann (1982) explores the relationship of scholar authors and the motivation for publication. Mann proposes five types of gratification, instrumental, prestige, reinforcement, aesthetic and respite derived from writing of literature. Mann (1982) critiques the scholar writer being primarily concerned with content rather than readership and explores the paradox of artistic success and commercial success.

Therefore my diary facilitated a useful learning tool to understand intrinsic motivation, which ultimately shaped the writing style and structure of the report**.** The journey of my DProf has refined my skills within experiential learning (Kolb, 1984) and reflective practice (Schon, 1983) representing learning as a cycle. The model considers the abstract and concrete ideas and the balance of academia within a real world. Such action research cycles are essential to understand practical application of my project, exploring real world problems, engaging with key stakeholders and using my knowledge and experience as continuous learning.

According to Alvesson and Deertz (2000) all research can be understood as a battle between distance and close upon, between being close upon the object and at the same time balance the distance. Therefore reflection as a researcher enables an exploration of objectivity and validity of this project.

Whitehead and McNiff (2006) use action reflection cycles of expressing concerns, saying why you are concerned in relation to values, imagining possibilities in developing action plans, acting and gathering data, evaluating the influences of action, modifying concerns, ideas and action in the light of the evaluations.

Navigating and traversing such roles to produce a mutually agreeable outcome is achieved by the nurturing of key stakeholders, as the intention is to maintain sustainability upon completion of the project. Therefore, I see my role within the field of IAQ extending beyond the role of this project. Upon reflection of my DProf, I have recognised that the journey has been the most important factor of shaping my development and knowledge. The DProf has taught me to be curious of the world and that an academic journey is not complete upon submission of a thesis. The field of IAQ is broad and limiting the project within boundaries has been the most challenging conflict.

Alvesson and Deetz (2000) stated that:

> '*The point of social science is not to get it right but to challenge guiding assumptions, fixed meanings and relations, and to reopen the formative capacity of human beings in relation to others and the world*' (Alvesson and Deetz, 2000, p107).

Often research is considered a process of data analysing and conclusions shaped for the intention of a selected audience. However the broad application of my research is an important factor. My values that drive this programme and the specific learning as a practitioner to assist with future development of IAQ is a strong influence, so therefore my research, although it has identified key stakeholders, will not be skewed by such and any epiphanies in learning to adapt to a diverse audience range will be considered. This has neighbouring parallels to Lather's (1991) view of empowerment, that in such a view:

> '*Empowerment is a process that one undertakes for oneself; it is not something done to or for someone' (*Lather, 1991, p4).

Thus my project is intended not just for an audience but also as a means of critical engagement with my own knowledge and understanding, to maintain my practice of reflection to enable me to continue this journey. Rogers (1967) describes a clean distillation of my own experience:

> '*I have come to feel that only learning which significantly influences behaviour is self-discovered self-appropriated learning. We can provide the opportunity, the environment, the encouragement … but the learning belongs ultimately to the learner*' (Rogers, 1967, p276).

Professional Practice

Throughout this paper, I have continued my full time career as an OHS professional, advising globally within a commercial organisation. The challenges faced to influence cost effective solutions for improving individual's health, safety and wellbeing, across geographically challenging time zones, cultures and diverse stakeholders, draw similar parallels to this project, which I have employed to assist with my project application.

My employer has witnessed my transition between a traditional OHS practitioner to an academic practitioner, exploring research and academic material to assist with developing a high culture of OHS programmes.

Within my own reflections I have experienced in previous roles how peers react to a scholar within their team; dismissing someone as an 'academic' is a disparaging stereotype indicating that their practical application or understanding of a commercial world would be diminished. The DProf programme has enabled me to traverse both worlds comfortably. I feel there is value in sharing my experiences of this programme to support the development of commercial businesses exploring the intrinsic motivations and values of academic practitioners within the workplace.

Within my current role, the supportive nature of my employer has enabled us to understand the role of academic practitioners; and indeed we have discussed this term and the development of reflective practice, critical thinking, action research and self-learning as a core skill required in our management development toolkits. Therefore the application and learning from this programme extends beyond the project boundaries and the arena of IAQ.

6.8 Personal Continuous Contribution

As discussed in previous chapters, Schon (1987) discusses action in the field, learning through experience and understanding the knowing how, as opposed to the knowing about. On a personal level this programme has enabled me to develop contextual tools for self-knowledge, discovering effective leadership and most importantly reflection that stimulates diverse and critical thinking.

As an OHS practitioner, I have started to contribute my knowledge via various media in addition to the IAQUK website, such as writing articles within the safety trade magazines (Bennett, 2006) and conference presentations. I have also lectured within existing university environmental health degree programmes.

This project has enabled me to network with stakeholders within the IAQ sphere. In particular, I have found that IAQ consultants offering monitoring services would welcome an independent body to register IAQ technicians and provide an accredited course to demonstrate competency,

Throughout this journey I have often felt pigeonholed by both practitioners and academics as to which arena I will continue my work within. I am now comfortable and I can remove the need to traverse between academia and a professional application and settle into my ‘academic practitioner’ role, as discussed on page 335. The epiphany of transformation into an academic practitioner has enabled me to work with credibility, leadership and self-assurance. Such influence has reflected in organisations looking to my current knowledge to develop the subject matter of IAQ further. Therefore I have discussed my future aspiration within my conclusion and recommendations chapter.

Wasserman and Kram (2009, p15), discuss that often scholar-practitioners have a continuum of rosponsibilities, as opposed to anchoring within one role:

> '*Individuals may place themselves at different points on the continuum as the emphasis in their work shifts, their careers unfold, and they form different partnerships and collaborations'* (Wasserman and Kram, 2009, p15).

Using my existing practitioner's skills I have refined my transferable skills of translating literature for on-academic audience (Casey 1986) into effective leadership and change management and produce actionable knowledge (Antonacopoulou, 2009). My learning journey has been challenging. It has not been a linear development as there have been many changes along the way which impacted on my progression and motivation. However I draw comfort from Campbell's (1968) the Hero's Journey, as discussed in my final chapter, page 337, which illustrates the journey from personal life challenges, pushing us outside our comfort zones, pushing us to accept either the choice or accepting or refusing the call of adventure. By accepting the call we let go of our old thinking patterns and face our demons, as we transform and emerge from the abyss.

6.9 Contribution of research to profession

This project was intended to be understand the contextualised setting and positioning of IAQ within UK, to use my experiences as an internal researcher, working with organisations and local authorities, to develop a cohesive body of understanding that contribution to the indoor air quality debate; in particular the transfer of embodied knowledge into contextual practices influencing key stakeholders for future sustainability.

My DProf project intended to be transformative rather than additive if it is to make a significant difference to IAQ competencies and practices. The transformative gaps were discussed and where voids existed the project activities intended to bridge such gaps, in particularly the review of IAQ competencies resulting in the development of the first UK dedicated IAQ accredited training course; following a literature review the lack of accessible resources resulted in the development of the first UK dedicated IAQ website portal.

Throughout this journey, a significant epiphany has been the lack of understanding towards the critical nature of IAQ, it also highlighted the need for an effective framework and leadership to drive IAQ via various channels of commercial and general public awareness.

The DProf programme intention was to firstly inform to allow further debates on the need for change; and secondly to provide a discussion with recommendation to steer such change. The complicities of integrating IAQ into local authorities and organisations is broad, therefore influencing and collaborating with key stakeholders will begin this journey. Throughout this programme I have engaged with OHS practitioners to local authorities and institutions in order to provide an intellectual synergy of opinions, with the intention of continuing my work and building on these relationships providing a platform for further debate.

6.10 Conclusions

Chapter 6 provides a parallel discussion regarding topics which I considered integral to the conversation of contextualising the setting and positioning of IAQ; to summarise key reflective points:

- The tolerability of risk framework would naturally exclude low risk agendas such as indoor air quality; the model fails to accommodate accumulative health concerns. Therefore as we strive towards self-regulation and risk based decisions regarding our environment, low risk hazards may be considered negligible, despite the social costs and financial benefits. A more effective model is required.
- The low risk agenda raised the question regarding body burden and the collective effects of the multitude of air contaminants within our environment and the lack of knowledge regarding the affects. Bio-monitoring has not been demonstrated as a priority within the Government's agenda. Questions regarding the lack of action should be directed to responsible authorities.
- Cost effectiveness models are difficult to demonstrate a linear relationship. However building designs should incorporate such factors which are equal to energy efficiency and may also be used as a commercial marketing indicator that effective IAQ could save resources.
- Influencing change and understanding within society is challenging and does not follow norms regarding risk perception and associated actions and behaviours. Further exploration is required to understand how to influence individuals to make choices regarding their environment that could be marketed as ardently as the unrelated organic movement.

- The DProf programme allows further debates on the need for change; and secondly to provide a discussion with recommendations to steer such change which is a powerful outcome and the legacy to this work.

Within chapter 7 I provide a conclusion and propose key recommendations. I summarise with a discussion of my journey through the DProf programme and include my future aspirations.

Chapter 7 –Conclusions and Recommendations

7.1 Conclusions

The main purpose of the project is to influence OHS and EH practitioners and the associated bodies' traditional thinking of indoor air quality within the workplace and contributing causes and management principals. As I reflect on my objectives on page 20, I have found table 1, which provided an outline of the project activities, helpful to ensure I achieved my objectives.

To conduct a literature review of IAQ to understand UK, European and global positioning, evaluating awareness and appraising future concerns;

- The literature review revealed the complexities and dynamic relationship of indoor air quality, including understanding political frameworks, risk perception. motivational factors to comply and emerging subjects such as perfumes. The literature review also raised further questions regarding the understanding and management of IAQ, which influenced my surveys.

To evaluate current IAQ understanding and risk perception of local authorities and OHS practitioners via two surveys;

- The surveys revealed how funding, society risk perception and political climate resulted in EHPs undertaking a reactive role, despite their desire to proactively engage with IAQ. The OHS practitioner's survey produced similar results, despite their dissatisfaction with their environment; their key challenges resulted in a lack of knowledge and understanding of IAQ. I would be interested to conduct a work-based research project with practitioners to explore the possibility of creating a cost effective model to demonstrate the benefits of effective air quality management

To provide an accessible, free, comprehensive IAQ intranet portal for general (lay) and expert readers;

- www.iaquk.org.uk was designed and developed by myself as a legacy to share free and accessible information. The website is growing in hit rates, thus demonstrating some form of satisfaction with the content. The progression of technology within the five years of completing my DProf programme has resulted in a broader range of internet hardwire, such as tablets and smart phones. Therefore, the website will need to be constantly reviewed to ensure the information is presented in the most suitable format for future technology.

To establish a UK indoor air quality OHS industry accredited awareness training programme with a national training body for OHS practitioners and other transdisplinary professionals;

- I developed and delivered an IOSH CPD IAQ course with excellent feedback from the students and IOSH training verifier. Since running this course, I have been asked to deliver a session in Northern Ireland to 50-100 delegates.

To develop recommendations for Government and associated bodies to take ownership for developing IAQ best practice.

- As detailed within this chapter.

In addition to my objectives, I also introduced an overall research question *what resources/discussions are required to raise the awareness of IAQ in the UK?*

- I feel this question still requires further development, particularly understanding society's risk perception and knowledge of IAQ, however this project has clearly indicated that knowledge and understanding are not enough to change attitudes and practices. The complexities of risk perception, cost modelling and political climate requires exploration.

A final challenge would be the stimulation of interest from relevant parties. Currently organisations do not prioritise indoor air quality alongside other topical issues. It does not seem to be important in the industry's perception.

From the history of IAQ we have understood the development that started in philosophy, later divided into, medicine and technology and in recent years has included a broad range of disciplines from building designs, HVAC engineering, architecture, occupational health, microbiology, sociology, psychology and economy, however many of these disciplines and the stakeholders who drive these factors have had little interaction.

The training for environmental health degree students have followed a similar approach, what is needed is a new multidisciplinary paradigm where generalised knowledge (putting findings in a total perspective) is as important as within-science knowledge. This project has led to the outcome of real data with tangible results that have a useful purpose within a responsible set of values and ethical considerations. Consciousness of the many connections between climate change and indoor air quality (IAQ) is relatively new.

However, anthropogenic climate change will have many impacts on IAQ and how indoor air is managed (Girman et al., 2008; Levin, 2007). Inevitably, as we attempt to reduce our carbon footprint, the energy use of buildings will attract more scrutiny. In the 1970's, one of the responses to the energy crisis was to reduce ventilation rates in buildings, with little consideration of the consequences of doing so. The result was a large increase in buildings with indoor air quality problems and increased exposure of the public to indoor air pollutants. Research is needed to provide energy efficient solutions to heating and cooling buildings without degrading indoor air quality**.**

The World Health Organization has established base limits for indoor air quality, countries including Norway, Germany and Poland have agreed target concentration levels. Australia has indicators of good air quality and defines quantity limits. The United States of America lead in good practice directed by the Indoor Air Quality Association.

Despite such advancements, the UK undoubtedly would benefit from establishing an indoor air quality framework which would provide further clarification to practitioners and to enforcement officers regulating standards and investigating complaints which is surely important if indoor concentrations of pollutants are to be controlled in a sustainable way.

Therefore within chapter seven, I have proposed recommendations that would challenge the positioning of IAQ in the UK. In particular:

- Labelling of products;
- Bio-monitoring and multi-pollutants framework;
- Education;
- IAQ Body.

As a concluding thought that parallels Silent Spring, until we start to co-ordinate our approach and resource effectively, without clear leadership, visibility and engagement, IAQ will become the sleeping giant of our nation's health.

7.2 Recommendations

Labelling of products

The UK have not adopted any labelling scheme regarding product emissions, although a few building material manufacturers have integrated volunteer testing using other countries schemes. Historically, labelling has focused on the building industry and materials used, however such measurement is complicated according to space, ventilation and application of product (i.e. applying paint to a wall using a brush or spray). Bluyssen et al., (2010) conducted interviews with producers of construction products, architects and housing corporations to understand how to reduce the impact of IAQ during construction stages. And concluded that although the stakeholders had knowledge regarding IAQ, they did not see how it related to their product/actions. They also stated that unless their user groups requested such products, the stakeholders are unlikely to take any action to improve IAQ within buildings. Bluyssen at al., (2010) recommended that an easy to understand labelling system should be compulsory on such products. Bluysenn et al., (2010) also cautioned against relying on sustainability approach to encourage engagement, as moral reasons are not supported by everyone. This further reinforced my discussion around health concerns and smoking, as consumers recognise the risk, but fail to change their habits to reduce exposure:

> *'Regulation seems to be the easiest way to promote IAQ. Linking to sustainability is not supported by everyone. Every way of educating people (information transfer) should be used, but transfer via the press and the media is considered to be the most effective. A 'fear-approach' should not be used. National campaigns could help to educate people. There is a need for classification of products, white lists, examples of good measures, emissions and specialist knowledge from experts'* (Bluysenn et al., 2010, p12).

The lack of labelling on products, particularly products like perfume who claim brand protection, reduces the ability for the consumer to understand the ingredients and make choices about their purchases. Chemicals can also have several names and unless classified by CAS, can again cause confusion. Currently any labelling schemes in the UK are voluntary and have no incentives. Labelling at the product level, would at least ascertain that the total emissions of products will be reduced over time and therefore the total amount of substances emitted to the air, will decrease.

Recommendations:

- European Directive for Energy Performance of Buildings (EPBD) EC, 2002) was approved in the beginning of 2003 and introduced into the UK in January 2006. Its objectives were to publish data on buildings introduced into the UK in January 2006, with the aim to achieve a sustainable environment and meet climate change targets agreed under the Kyoto Protocol (Conference of the Parties, 1997).

  The integration of an IAQ performance data into the EPCs, thus ensuring new buildings meet the standards and existing owners were aware of the impact of emissions from products and materials and understand sufficient ventilation rates. This will ensure that energy efficiency is not designed to the detriment of occupants as specified within the EPBD directive.
- I would also recommend that labelling of ingredients, materials, emissions is compulsory; as we have seen with food that has been driven by the consumer. Introducing a traffic light label to indicate high or low emissions assists the consumer to interpret the data. It would also act as a powerful motivator for manufacturers to lower emissions.
- Finally, the definitions of no perfume or perfume-free are to be reviewed; even if an odour is not detectable, but still emits emissions, it should be identified as such.

Bio-Monitoring and Multi-pollutant framework

Demonstrating a relationship between single and combined components and the impact on occupants is vague. Whilst we continue to research silo contaminants, regulate exposure limits based on single pollutants and fail to extend the impact on human health to psychological conditions, the cost model for controlling and managing IAQ will be limited.

The complexities of combined contaminants, the reaction from different individuals, the perception of risk against actual and the variations during exposure, such as ventilation rates, temperature, occupants density can add further permutations. Bio-monitoring will enable a clearer understanding of physiological, psychological and perception impacts providing a clear evaluation of actual interactions from a mixture of pollutants.

Recommendations:

- An introduction of a strategy and methodology for multi-pollutant research in Europe led and enforced by SCHER. For a harmonised and structured approach, SCHER should also publicly report data and findings of bio-monitoring and multi-pollutant research and publish performance tables of countries actions.
- There is no lack of desire to achieve this objective within the IAQ community, funding is the critical requirement and therefore the SCHER should be support by government organisations with appropriate funding.

Education

There is a clear gap of acknowledgement between government organisations, within the triple helix model, and beyond the UK with global organisations and research. There is no clear leadership, accountability of roles and responsibilities. Aside from the strategic level of knowledge gaps, consumers and occupants are unaware of the risks and the visibility of IAQ.

There is a lack of direction and strategic approach to education, whether considering learning and awareness in schools (Bluyssen et al., 2010) to construction stakeholders (architects, housing corporations, contractors) Vittori (2002) through to technical competencies within OSH Practitioner's CPD and/or degree programmes. There are no formally recognised training and the introduction of my project activity's IAQ into IOSH's CPD programme is the first in the UK.

Recommendations:

- Following completion of my DProf programme, I intend to explore future training and educational methods to appraise competencies and knowledge requirements for stakeholders, such as surveyors of EPC assessments for IAQ, training for architects, inclusion in EHP degree programmes and health and safety. Establishment of IAQ training for practitioners to regulation competencies in the workplace.
- Development of competency courses for HVAC technicians, such as City & Guilds.
- Development of a communication strategy to introduce education and awareness using a "*push & pull*" approach for society and schools.
- Such recommendations should be actively managed by an IAQ body.

IAQ Body

To assist with the dissemination and development, an independent IAQ body should be established to provide a central portal for local government and the public to gain access to information regarding IAQ. The body should provide a unique voice and ensure visibility is not lost amongst the adjoining dialogues of building design and sustainability. The body could perform a number of roles:

- Strategic visioning and goal mapping for future developments;
- Developing cost-benefit analysis/economic instruments regarding the implementation of IAQ modelling;
- Promoting and improving the delivery of systemic and integrated IAQ services to the public;
- Regulate IAQ practitioner's conducting monitoring activities;
- Provide a portal/resource for the public to access;
- Improve competency standards for practitioners and regulate IAQ educational programmes;
- Liaise with professional and educational institutes on the promotion of IAQ matters;
- Collaborate with the building sector and manufacturers to encourage self-regulation;
- Encourage further research activity within the IAQ sphere.

As mentioned within my previous literature research, there is a disjointed approach to IAQ within countries. The US has evolved the most sustainable approach, with the Indoor Air Quality Association (IAQA) established in 1995 to promote standards and procedures and to deliver accredited training. They aim their resources at both consumers and industry. The perception of risk from indoor air contaminants and the willingness to improve indoor air quality is contrasted by the lack of standards, direction and information within the public sphere.

Therefore it is much more difficult to provide policy-makers with steerage and economic resources, encouraging manufacturers to test and reduce contaminants, collaborating with building designers and maintenance to improve ventilation designs and building materials and the consumer to purchase low emitting air contaminants. I have illustrated in figure 36, below, the potential structure of an IAQ body and their interaction between the various organisations.

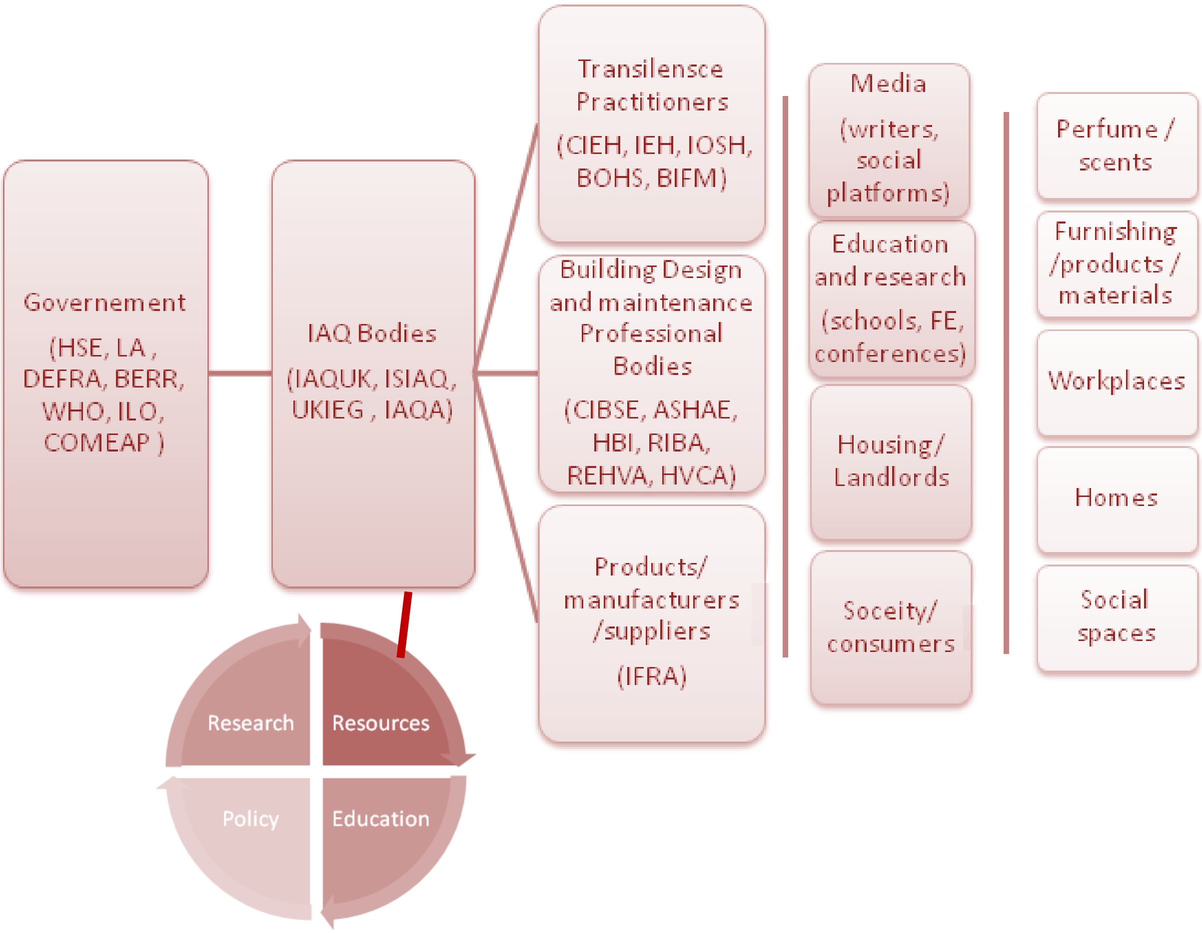

Figure 36: Areas of consideration for policy makers.
Structure and communication channels of an IAQ body.

Rational debate in a democracy requires that adequate information is available to all, thereby giving a choice to consumers and occupants regarding air contaminants, which does not exist in the UK.

Due to the diverse nature of IAQ, societal change is required. That is, there are areas where traditional regulation is not feasible; the key drive is by influencing behaviour and choices. This means that a substantial educational effort is required in much the same way that education has been used to reduce active smoking or drink driving in the community.

Further research is required in the following areas to assist with building an effective framework for the implementation of a sustainable IAQ agenda:

- Establish a working party of a broad spectrum of stakeholders to continue the debate of IAQ;
- Introduction of a labelling scheme to provide information for consumers;
- Provide clear risk education to local authorities and OSH practitioners via CPD and degree programme;
- Introduce environmental certification;
- Encourage further research within the spectrum of transformational projects to assist with development cost effective models and management tools.

7.3 Dissemination

Thorne (1999) explores the dissemination process and questions whether dissemination is seen as a method for young students to advance their career, recognising that the mature students did not value such rationale. Thorne also discussed that professional doctorate students also did not value presenting their findings at conferences to publicise their work. Within my own professional role, I have presented at many conferences and indeed presented research in the House of Commons, therefore I value such channels and recognise that aside from traditional methods of publishing work within academic databases, including 'eprints', to ensure transferability of findings to non-academic audiences, commercial avenues need to be incorporated. Therefore following the completion of my Doctorate, I will engage with such stakeholders to arrange.

Although IAQ is not new and there have many papers written about the effects of IAQ, I would propose to deliver a broader understanding of the importance, the barriers to implement and the business and moral considerations of benefits. My website and training will also act as a legacy for future dissemination to ensure a blending of knowledge and insight from the academic arena into a real world environment. As discussed within my project, the societal concern is an interesting avenue to explore and I would consider speaking/writing for lay readers within the organic and environment spheres to generate interest. I also intend to share my findings with government bodies, including DEFRA, DOH and the HSE. I have spoken to the HSE publications department prior to the commencement of my DProf regarding the proposal of developing a free IAQ booklet for their readers available on their HSE books website; this idea was rejected due to subject matter being perceived as not relevant to the HSE's aims. Upon completion, the doctorate may provide weight to the discussion and allow for further debate.

As an outcome from my discussions with the Government bodies, I would like to see an inclusion of IAQ within the degree syllabus for EHPs; my IOSH certification may provide creditability to such relevance. During the past five years, I have already trial such materials for BSc and MSc health and safety degree students as a method of dissemination.

As a professional student, my knowledge of commercial media and the channels used to communicate will be employed, including an extension to my website to include a blog as a method of quick accessible information for lay readers (Brumfiel, 2009) (Walejko and Ksiazek, 2010). A driver of my project was to create knowledge and understanding, to ultimately bring about change in the visibility of IAQ in the UK. Although such conversations are unquantifiable with regards to outcome, they will stimulate debate and consideration for new research projects for the future.

Upon completion of this project, I presented my findings at the UK Indoor Environments Group (UKIEG) 2013 conference on the 4th June 2013.. The event is a networking event for a multidisciplinary audience of academics, policy makers and industry experts with an interest in improving indoor environments for health and wellbeing. The aim of the event is to address the future challenges and latest research evidence on the factors affecting health and wellbeing in buildings.

During the writing of this thesis, I prepared an abstract about my thesis for the UKIEG conference (UK Indoor Environmental Group). The abstract was accepted, along with a short powerpoint presentation on this project. Details of my abstract submission, UKIEG programme details and poster presentation are contained within appendixes 16, 17 and 18, pages 487, 489 and 490. The conference was held on the 4th June 2013 in London.

7.4 The DProf Journey – Critical Reflections

At the commencement of my doctorate, I considered the output from my findings the most important factor in my project, however during the programme, I have chronicled an ethnographic account of my struggles and epiphanies of my own action learning which is fundamental to a professional doctorate. Therefore I have included a section on my reflective account, the hero's journey and my future aspirations. In doing so, I hope I have brought some objectivity to my study, which will mean that my conclusions might be understood and used by others.

Throughout my five years I have been hesitant to expose any weakness in my work, by internalising my thoughts and journey, reluctant to ask for assistance and guidance. Thus this chapter is illuminating for me; it provides additional depth and purpose for my future journey.

I feel much resonance with Solomon's comments:

> *'Reflection is not just deck-chair musing.'* and *'we all need to hold out our ideas to other people, and receive their responses, not just to hear their criticism and approval but also to understand better our own views of the world'* (Solomon 1987, p271).

7.4.1 The practice of reflection

I reflect on Kolb, (1984) Experiential Learning Theory (ELT) whereby knowledge is continuously gained through both personal and environmental experiences. He states that in order to gain genuine knowledge from an experience, certain abilities are required including a willingness to learn, reflecting on experience, learning to resolve conflicts and understanding how to transform knowledge into experience. Such application of detachment and objectivity on experience has its critics (Illeris, 2007) who suggests that it did not meet the needs of professionals who need to think on their feet.

Moon (1999) discusses this application of noticing, making sense, making meaning, working with meaning and transformative learning as a reflective model. This model identifies a deeper layer of learning that influences reflective activities. Mann et al., (2009) discuss the different dimensions of models, indicating reflective models, such as Schon (1983) is an iterative model which is triggered by experience that generates new knowledge, whereby Dewey (1933) and Moon (1999) are vertical models which uses different levels of reflection and experience. Throughout this project I have used a vertical model which is typical within my work as a practitioner. Practitioners need to be able to problem-solve, influence stakeholders, articulate argument, work collaboratively with silo organisations and therefore the development of this project has demonstrated a range of capacities beyond technical knowledge. Moon (2004) further suggests that emotion, or fatigue, Boenink et al., (2004), is also influential on the learning process, which can encourage or discourage the application of learning. As a practitioner I can be influenced by the level of value I place on the learning, compared with competing demands (represented similar value in managing risk and the perception of which risk is most critical). Therefore consideration for reflective practice and the analytical approach to reflective activities should be considered ensuring an authentic, professional approach.

Aside from the barriers of emotion and fatigue, Mamede and Schmidt (2005) discuss how reflection can decrease over longevity within a role and with time constraints or pressure, both of which I am exposed to within my current role. Therefore understanding the moments of reflections and harnessing such knowledge is critical. Michelson (1998) discusses the moment of learning, in which there is a mental and physical response, which one might term as a light-bulb moment, however this would acquire you to be conscious of your learning moment. Although such learning points may be obvious, I believe we learn through less obvious medias, including subliminal influences, perception, emotions, memory; and they may have different hierarchy effect of influencing our behaviour, but none-the-less they have value. This raises a self-critical point of if my learning is stimulated by the need to acquire new competencies and only applied for such environments, or do I allow reflective thinking to imbue day to day thoughts as a natural stream of consciousness to stimulate the need for learning.

Contemplating my self-development, the DProf journey has been characterised by a number of components, including development of my core knowledge surrounding IAQ and the dynamic understanding of political, social and economic positioning, the engagement with abstract, human-related and previously undervalued and heterogeneous knowledge has assisted with the development of my DProf objectives and project. I am able to critically analyse my progression as a practitioner, balancing academic and OHS professional practice, actively incorporating reflection, analytical skills, leadership and change management into my skill sets as a practitioner as I look to the horizon, creating a greater self-awareness, which further induces self–managed learning. From the various papers, guides and how to tips on reflective practice, perhaps the most influential for me is to be conscious of all moments of learning and the internalising of such knowledge, being aware of my reactions and emotions. By maintaining my journal, such learning, regardless of whether it was understood and applied at the time, can record thoughts as an accompaniment to my continuous learning.

7.4.2 Academic Practitioner / Leader

Academic Practitioner

Throughout my DProf journey I have embraced my ability to traverse between an academic and practitioner role, navigating my position as an internal researcher transferring knowledge into a commercial application. I have used my professional competencies within a practitioner role to explore the paradigm shift of IAQ aligning knowledge with a transdiscipinary application across my triple helix stakeholders. Such proficiency has enabled me to shape my own work based learning, traversing the role of academic and practitioner, Huff and Huff (2001) describe such application as a boundary-spanner:

> '*Who potentially closes the relevance gap from both ends' of science and business? (*Huff and Huff 2001, p50).

To a pure academic, the most important emphasis in life is research, theory and knowledge (Kormanik, at el, 2009), such parallel application can reduce the viability of such knowledge if information is pooled without application.
The "pouring in" of knowledge (Macrine, 2009), is a deficit model of learning that portrays learners as passive recipients who are not engaged in the development of new knowledge, but just superficially regurgitating facts. Conversely, a pure practitioner interprets knowledge, sometimes regardless of reliability or validity or even induced by pop theories, which lack theoretical context and evidence. Value is new knowledge that leads to new practices; the linkage between theory and practice must be made in order for the knowledge to be actionable.

> *'Actionable scientific knowledge refers to the knowledge creation process that meets the criteria and needs of both the scientific community and the organisation'* (Adler et al., 2004, p84).

A link is established in the form of a scholar-practitioner, with various terms discussed more and more at academic and practitioner conferences as well as in literature (Wasserman and Kram 2009). In addition to the phrase scholar-practitioner, this role has been called reflective practitioner (Schon 1983), practitioner-researcher (Quigley 2000), practitioner-academics (Simendinger, et al 2000) and prac-academic (Aram & Salipante 2002). Essentially the phrases draw minimum distinction and are dependent on the context of use. I consider myself a practitioner with an academic influence and refer to my phrase of 'academic practitioner', As an academic practitioner and under the umbrella of a work based learning project, I participated within this project as an internal researcher who understands the complexities of applying a theoretical knowledge into real-world situations. Despite the advantages of such perspective, I am epitomized within my role as a DProf student as discussed by Fillery-Travis and Tyrrell (2012).

> *'They can be less concerned with generalisability of research results and more interested in their usefulness within a specific context'. (*Fillery-Travis and Tyrrell, 2012, p3).

Such reflection has resulted in the changing of my programme plan on several occasions as my insider knowledge has evolved, my project has stimulated further debate and discussions. I have found a dilemma to work based learning approach that such rigorous methodology can restrict the exploration of variables within a practical world application and therefore reflective practice and critical thinking has been a companion to create boundaries within my project to ensure viability and creditability. I would propose a third dimension to the academic–practitioner model and suggest for significant transposing of theory into practice, change management is to occur for sustainable workplace contributions and I suggest leadership to deliver beyond integrating theoretical and application-based knowledge, presented in the value of an 'academic leader'. I am exploring this position within my own employment role as a global leader within a commercial industry, using academic and practitioner roles to steer strategic objectives.

7.4.3 Hero's Journey

As discussed in chapter 6, I draw comfort from Campbell's (1949) the Hero's Journey. Campbell (1968) suggests all heroic stories of adventure have a cycle of departure, initiation and return. The premise is that the journey is a rite of passage whereby the individual undergoes a transformation, in my case leaving behind old ways of thinking, being and displaying a new level of consciousness and development. Although I may not be slaying mythological beasts, there is an intrinsic emotion of wrestling with one's own demons.

The DProf tests your mental strength, health and personal relationships; along the journey I have continual questioned my ability and application, becoming frustrated at my lack of progress. In terms of my own journey, I do not see myself as a hero, but I do draws parallels to the barriers that exist and the rewards from sustainability to navigate the narrative Hero's arc. In contrast to the literature detailing the anxiety, stress, self-doubt and debilitating effects of a doctorate (Bartlett & Mercer, 2001; Lee & Williams, 1999), Mowbray and Hales (2010) argue that struggles have a productive and positive impact that builds resilience, resourcefulness and problem-solving skills.

As I commenced my journey, although acceptant, I was unsure of what it would look like or the final destination, you are looking into the abyss and although my programme leader and academic supervisor have guided me, the journey is a personal experience that can only be defined by your own experiences, doubts, fears, frustration and eventually joy (relief). Upon completion of the cycle you should be transformed and thereafter the cycle begins again as you continue to use new found knowledge and skills to constantly challenge yourself.

The five years of my study have been a personal transformation during which I have challenged my own views on my role as an academic practitioner, my understanding of reflection, professional application and indeed an evaluation of my own motivation and drivers.

The journey has stretched my intellectual capacity, beyond IAQ, including multi-method approaches, action research, methodology considerations, triangulation, transferability of literature, change management and ethical considerations; it has also refined transferable skills:

> *'Within the DProf the idea of autonomous scholar is replaced to some extent by the concept of an advanced practitioner who has mastered the 'practices of self'- self appraisal/reflection on practice, self regulation and self examination'* (Fillery-Travis, 2012, p14).

Brailsford (2010) questions the rationale of why a mature students decides to undertake a PhD, suggesting that sigfificnat number of student fail and those that succeed stagger pver the finishing line exhausted. These thoughts are echoed by my own experience, through cycles of doubt and exhaustion during the five years. Brailsford (2010) does offer guidance to validate my journey by acknowledging the insight of the initial motives for completing a doctorate, which can be multiple and complex.

The surveying of doctorate students has developed from Churchill and Sanders (2007) suggest personal reasons such as career development, personal agenda, lack of job satisfaction; Gill and Hoppe's (2009) five traits from traditional entry, professional development, professional advancement, transitional and personal fulfilment; none of which I can relate to within my own experience. Reading Selmer and Grahams's (2011) account of three female doctorate experiences, the correlation of experiences are similar, however the motivations are very individual.

I would perhaps refer to Salmon's (1992) suggestion that social science PhD students are motivated by social justice concerns and a sense of identity. My driver is to create a legacy of change and awareness to an issue I feel passionate about, therefore I am conscious not to lose sight of my initial motivational factors and the continued journey upon completion of my doctorate; and therefore transcribing my future aspirations will be a constant reminder of the next stages of my commitment.

7.4.4 Future Aspirations

My passion and knowledge for IAQ has continued to evolve throughout the DProf programme and has enabled me to identify gaps within the visibility and implementation of standards within the UK. As I draw near to completion of this project, I recognise my work is not complete and I am intending to continue this journey with the purpose of influencing the key stakeholders mentioned within this project. Therefore since writing the findings for this project, I have continued my activities as detailed in appendix 20, which include exploring the possibility of introducing an IOSH IAQ group, establish discussions with educational institutions to integrate IAQ onto their training programmes and to continue to write and speak about IAQ to maintain understanding and engagement.

I am passionate about my persistence in their belief to warn others about the potentially devastating effects of indoor air pollutants. Collectively the objectives have changed and evolved throughout the DProf journey, however essentially the underlying aim has been consistent with regards to raising the awareness and knowledge of IAQ in the UK. The evolving journey has influenced my development as a student understanding my unique role in implementing change, developing innovative approaches and creating sustainable solutions to complex issues (Lester, 2004).

I can reflect and see the progression in my work and writing and have learnt valuable skills, in particular leadership and reflective practices which will ultimately shape my career. The understanding of continuous professional development will be a constant companion as I continue my journey. The DProf has been a life changing experience and further to the knowledge and skills gained, it has also stimulated a reflection of my professional career. Upon completion of this project, the completion of my appetite for study will never be suppressed and I will fail to acknowledge what has been done or achieved... but what remains to be done... and so the journey continues...

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9. Appendices

Appendix 1 – Comparable studies of IAQ

Study	**Outcome**
Burge, Hedge, Wilson, Bass (1987)	Lethargy accounted for 57%, headaches 43%, stuffy nose 47% and itchy eyes 27%. In addition respondents thought their work reduced their productivity by 20% or more.
Raw G, Roys M and Leaman (1990).	Productivity is reduced by 2.8% when an employee suffers from three SBS symptoms.
Robertson, Roberts & Burge (1990)	There were six days per hundred workers per month less sickness absence in workers from naturally ventilated offices in a group moving to and from a central air conditioned building.
Seppänen (1999).	Some calculations show that the estimated cost of deteriorated indoor environment is higher than the heating energy costs of the same buildings.
Fisk (2000)	For the United States, the estimated potential annual savings and productivity gains are $6 to $14 billion from reduced respiratory disease, $1 to $4 billion from reduced allergies and asthma, $10 to $30 billion from reduced sick building syndrome symptoms, and $20 to $160 billion from direct improvements in worker performance that are unrelated to health.
Federspiel (2001)	Analysed data from 575 buildings and reported that 18.4% of complaints were IAQ complaints. 77% of IAQ complaints were about conditions perceived as too hot or too cold. He showed that the rate of complaints depends on the average temperature and its standard deviation and he estimated maintenance cost savings of $0.0035/ft2 per year.

Seppänen and Vuolle. (2000)	Conducting cases studies to model IAQ and concluded 1.5% work performance increase by doubling the ventilation, resulting in £1,000 savings per 1% per person increase, per year
Djukanovic, Wargocki and Fanger (2002)	The performance of office work can be increased by 1.1% for every 10% reduction in the proportion of persons dissatisfied with the air quality, by 1.6% for every twofold decrease of pollution load, and by 1.8% for every twofold increase of the ventilation rate (outdoor air supply rate).
Tuomainen, Smolander, Kurnitski, Palonen and Seppanen (2002)	In most buildings the capacity of the HVAC system is sufficient to increase the ventilation rate without investments in new equipment. Therefore, the ratio of the benefits of increased ventilation, i.e. higher productivity, compared with the costs of higher energy consumption result in €135 / €11.7 - 11.5. The benefits are approximately 11 times greater than the costs.
Burge, (2004).	Within a large government office with 2500 occupants, assuming one day's sickness absence per year attributed to sick building syndrome and one hour per month dealing with or complaining about the indoor environment. At 1990 prices the costs to the organisation were £400,000 for one year.
Fisk, Seppäne, Faulkner and Huang (2004)	In the modelled 72-person office building, the analyses indicated that the effective management reduces energy costs by approximately $2000 and, in addition, reduces sick leave. The annual financial benefit of the decrease in sick leave is estimated to be between $6,000 and $16,000.
Seppänen, Fisk and Faulkner (2004)	Performance increases with temperature up to 21-22 ^{o}C and that performance decreases with temperature above 23-24 ^{o}C.

Seppanen, Fisk and Lei (2006)	The studies indicated typically a 1-3% improvement in average performance per 10 L/s-person increase in outdoor air ventilation rate. The performance increased per unit when ventilation was bigger with ventilation rates below 20 L/s-person and almost negligible with ventilation rates over 45 L/s-person. The performance increase was statistically significant with increased ventilation rates up to 15 L/s-person with 95% CI and up to 17 L/s-person with 90% C.
Mendell, Lei, Apte and Fisk (2007).	Occupancy density, with constant ventilation per person by any method, was associated with an approximately 20-40% increased odds of SBS symptoms at all densities greater than about 2.5 persons per 1,000 sq ft.
Fisk, Mirer, and Mendell (2009)	Average prevalence of SBS symptoms increases by approximately 23% as the ventilation rate drops from 10 to 5 L/s-p and decreases by approximately 29% as ventilation rate increases from 10 to 25 L/s-person.

Appendix 2 – Table 27: Seppanen and Fisk (2004) cost effectiveness model explanation

Adverse human responses (#3-9) to the indoor environment range from infectious diseases to complaints. The evidence of the effect of indoor environment on these human responses varies with outcome. Some infectious respiratory diseases (#3) are known to be transmitted, in part, by aerosols. These diseases include such as common colds (e.g. rhinovirus infections), influenza, and adenovirus infections. In the United States, four common respiratory illnesses (common cold, influenza, pneumonia and bronchitis) cause 176 million days lost from work and additional 121 million working days of substantially restricted activity (Fisk 2000). *Although the primary causes of asthma and allergy (#4) are not necessarily related to buildings, the prevalence and severity of symptoms are commonly related to building factors. The cost of allergy and asthma is high, estimated to be only in the US $15 billion per year (Fisk 2000). Other building related illnesses (#5) include humidifier fever, Legionnaire's disease, heart and lung diseases due to environmental tobacco smoke, and lung cancer due to radon exposure. SBS symptoms (#6) are probably most commonly used outcomes in health-related building studies. The representative data from US office buildings found that 23% of office workers (15 million workers) reported two or more frequent sick building syndrome symptoms that improved when they were away from the work place (Fisk 2000).* *The thermal environment (#7) is not ideal in many buildings. Shortage of cooling or heating capacity, high internal or external loads or poor control systems may lead to unacceptable temporal or spatial variation of the temperatures in a building. The relation between building design and operation, and thermal conditions is established with many building simulation tools. Some of these tools estimate for human comfort. While criteria for thermal comfort are well established, the thermal environment may also have a direct link to work* performance and thermal conditions may affect SBS symptoms through an unknown mechanism. Figure 1 does not show all of these linkages. Perceived indoor air quality (PAQ) (#8) has been commonly used as a metric of human response to indoor air quality, and ventilation rates. It can be evaluated in real buildings semi-quantitatively with trained or untrained olfactory panels. Many ventilation standards are based on the dilution of body odor by ventilation and the resulting PAQ. Perceived air quality is affected mainly by pollution sources in the building, ventilation rates, outdoor air quality, and air temperature and humidity. Complaints about indoor environments (#9) to facility management are very common. Federspiel (2001) has shown that responses to temperature-related complaints impose a significant cost in office buildings. Seppanen and Fisk (2004, p4)

Appendix 3 - Extract from email sent to local authorities

I am writing to you with regards to my PhD research I am conducting and would be grateful if you would be able to assist with providing some feedback via the attached questionnaire in excel (a PDF copy also attached).

IAQ Survey.xls (76 KB) IAQ Survey.pdf (31 KB)

<u>Purpose of the research</u>

My research focuses on indoor air quality (IAQ). With work environments becoming more energy efficient, use of more synthetic materials and chemical and unacceptable cocktails of emissions and the use of odour brand marketing in a over saturated visual and audio market, the agenda of IAQ is becoming paramount. There are numerous organisations which are in charge of different aspects of indoor air quality, of which the sources of information are disparate. There is a clear need to address indoor air quality more seriously and effectively, which should include a coordinated approach by the various organisations.

Managing indoor air quality is challenging because it crosses many disciplinary boundaries, from architecture, and building design to occupational health and human behaviour; and covers many types of variables relating to buildings, including their layout and technology, the organisations which occupy them, the management styles and the people themselves.

Despite health being an important issues to people's lives, studies have shown that people remain unaware and often apathetic of the health risks posed from indoor air. This could be argued understandable when comparing priorities of high risk activities and hazards. However the effects of indoor air quality is indispensable in the economic impact in the workplace, which is the justification of my proposal.

My objective is to establish an independent organisation that champions IAQ within the UK. Thus raising the agenda of IAQ by working with the various agents and organisations in promoting indoor air quality and ensuring the information is accessible to enable individuals to become educated about their environment by:

- Providing a comprehensive reference source for the UK regarding indoor air quality.
- Establishing UK indoor air quality accredited training certificate with national training body for practitioners and students.
- Influencing IAQ practitioner's competence standards.
- Influencing Government and associated national bodies to take ownership of developing IAQ best practice.
- Consolidating knowledge and standards from silo disciplines.

I am interested in bring the different disciplines together, raising the profile through various safety, facilities and building management groups, unions, trade organisations and councils, establishing a competence for practitioners.

I am engaged with various projects currently such as the introduction of the first Indoor Air Quality training programme onto IOSH CPD Training programme for 2011. I have a few articles due for publication within trade and national press, I also lecturer at a few universities for environmental health degree students regarding the subject and currently evaluating degree programmes within Building Sciences and Environmental Health across the UK. Currently I am in the stages of developing a free IAQ portal for information.- www.iaquk.org.uk. (The website will provide further details regarding my work).

How long will it take to complete the questionnaire?

The questionnaire should take approximately 5 – 10 minutes to complete. Completed questionnaires to be emailed to julieriggs@btinternet.com. Submissions required by 31st January 2011.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part completing the attached questionnaire will be taken as accepted consent. If you decide to take part you are still free to withdraw at any time and without giving a reason

What are the possible benefits of taking part?

The information we get from this study will help us understand how to raise the agenda of indoor air quality within the home and work and understand the resources required in working with the various agents and organisations in promoting indoor air quality, ensuring the information is accessible to enable individuals to make a choice about their environment

Will my taking part in this study be kept confidential?

All information that is collected about you during the course of the research will be kept strictly confidential. All data, whether written or computerised, will be kept secure in accordance with the Data Protection Act 1998, thus maintaining anonymity of individuals and the organisation.

What will happen to the results of the research study?

The results will be published as part of a post graduate Professional Doctorate degree. Completion of the thesis is expected to be due in September 2012. Copies of the document are also available for you on request. Please provide an email contact on the questionnaire should you wish to receive an electronic copy. To clarify no participants/organisations will be identified within any report or publication.

Researcher's background

I have worked as a health and safety practitioner for the past 15 years in a wide range of industries. I have been interviewed by a Times Reporter and featured in a safety trade journey detailing the development of my career. I have also featured in two radio 4 programme discussing my work and research. I have presented at the House of Commons joint sponsored research with the CIPD with published findings in the FT.

During this time I have completed a Health & Safety Management MSc with distinction from Middlesex University; focusing on indoor air quality I have continued my studies, currently completing a PhD, within the field of IAQ. I work full-time as a Health and Safety practitioner, but do not offer any IAQ services and do not intend to gain any financial or commercial benefits from the IAQ UK activities.

I am happy to provide a copy of my CV on request and provide further clarification of my background. I have recently developed an IAQUK website which details further commentary around my work. http://iaquk.org.uk/about.html
Many thanks for your time and cooperation. If there is any further information I can provide, please do not hesitate to contact me.
Kind regards
Julie Riggs

Appendix 4 – IAQ Survey sent to local authorities and raw data results

Indoor Air Quality Survey

Council Name ____________ Date ____________

Name ____________

Job Title ____________ Optional Email ____________

Department ____________ *Should you require a copy of the findings*

Please indicate within boxes using a symbol (such as x) / Please use the lines for further written text

This questionnaire should take approximately 5-10 minutes to complete. Please save and email to julieriggs@btinternet.com when completed

No identification of your name or organisation will be published within the research.

Significance of Indoor Air Quality (IAQ)

Please rate the importance of health risk with regards to the following topics

Importance -	None	Low	Indifferent	Reasonable	Significant
Mobile phone towers	12	55	4	5	6
Insecticides and weed killer residuals in food	8	59	11	1	3
Food poisoning	8	13	2	8	51
Obesity	3	1	8	45	25
Air pollution from cars	0	0	2	8	72
Air pollutions from factories	0	3	0	12	67
Indoor air quality within a sealed HVAC building	4	47	1	27	3
Indoor air quality within a naturally ventilated building	1	56	1	23	1
Stress	0	4	0	73	5
Cigarette smoking	0	0	0	3	79
Drinking alcohol	2	5	1	18	56
Chemicals/additives in food/drinks	1	11	9	52	9
Chemicals in beauty products	1	64	12	5	0

Please compare the importance of indoor air quality with regards to health impact with other environmental considerations

Importance -	None	Low	Indifferent	Reasonable	Significant
Indoor Air Quality	0	2	0	68	12
Outdoor Air Quality	0	3	0	48	31
Noise (nuisance)	2	1	0	29	50
Water pollution	1	2	0	73	6
Asbestos	0	0	1	13	68
Land pollution	2	5	8	49	20

Please rate the impact of proactive IAQ with regards to

Impact -	None	Low	Indifferent	Reasonable	Significant
Reducing health care costs of occupants	0	0	2	73	7
Improving building performance/energy efficiency	0	0	5	53	24
Improving comfort of occupants	0	34	8	36	4
Improving productivity of occupants	2	43	13	21	3

Which indoor air contaminants appears to present the greatest health risks

Importance -	None	Low	Indifferent	Reasonable	Significant
Mould/Dampness	2	1	5	34	40
Carbon Dioxide	4	15	34	12	17
Volatile Organic Compounds (VOCs)	2	2	3	19	56
Benzene	0	0	1	14	67
Carbon Monoxide	0	0	0	4	78
Dust	0	4	1	54	23
Biological matters	0	3	1	49	29
Odours/Perfumes	5	71	5	0	1
Low/High temperature	7	65	0	8	2
Low/High Humidity	9	72	0	0	1

Rate the impact poor indoor air quality may have on the following conditions

Impact -	None	Low	Indifferent	Reasonable	Significant
Asthma attack	1	0	0	2	79
Dryness/Irritation to skin	0	1	11	67	3
Dermatitis	0	1	16	63	2
Dryness/Irritation to eyes	1	2	15	61	3
Irritated nose / sinus	0	2	12	65	3
Tiredness	1	6	32	27	16
Stress	0	6	26	34	16
Anxiety	5	33	26	15	3
Depression	9	17	36	16	4
Headaches	3	23	13	17	26
Migraines	1	6	44	23	8
Raised blood pressure	0	6	21	42	13
Other (please indicate below)					

Rate the importance of the following causes of poor indoor air quality (IAQ)

Importance -	None	Low	Indifferent	Reasonable	Significant
Inadequate ventilation	0	1	1	4	76
Contamination from outside the building (petrol fumes etc)	1	3	2	17	59
Contamination from internal building fabric/finishes (paint)	7	38	29	5	3
Too hot/cold	2	56	20	2	0
Too dry/humid	3	52	23	3	1
Artificial perfumes/nuisance odours	6	73	2	0	1
Inability to control temp/vent locally (due to HVAC)	14	67	0	2	0
Other (please indicate below)					

Further comments

Management of Indoor Air Quality (IAQ)

Please indicate your key reasons for indoor air quality monitoring

	Yes	No	Average % of reasons
Due to compliant	77	5	90 %
Due to sickness/ill health	73	9	8 %
Proactive schedule monitoring	1	81	2 %
Due to needs of a project/build	0	82	0 %
Other (please indicate below)			

Please indicate your key reasons for outdoor air quality monitoring

	Yes	No	Average % of reasons
Due to compliant	79	3	98 %
Due to sickness/ill health	0	82	0 %
Proactive schedule monitoring	2	80	2 %
Due to needs of a project/build	0	82	0 %
Other (please indicate below)			

Which % of sources generate complaints regarding indoor air quality (IAQ)?

	Yes	No	Average % of complaints
Educational Facilities (Schools, FE, HE)	9	73	1 %
Housing - Private	81	1	35 %
Housing -Social	69	13	29 %
Commercial (please indicate types below)	79	3	35 %

Which of the following indoor air contaminants do you receive the greatest complaints

Number of complaints -	None	Low	Indifferent	Reasonable	Significant
Mould/Dampness	0	56	4	15	7
Carbon Dioxide	13	51	16	2	0
Volatile Organic Compounds (VOCs)	0	75	2	4	1
Benzene	21	59	2	0	0
Carbon Monoxide	2	78	1	1	0
Dust	1	51	0	23	7
Biological matters	1	79	2	0	0
Odours/Perfumes	1	22	0	44	15
Low/High temperature	0	16	0	63	3
Low/High Humidity	2	27	1	52	0

Please indicate whether you have the following resources within your organisation

	Yes	No
Dedicated IAQ Officer(s)	7	75
Contact details for the public to raise concerns	78	4
IAQ Policy	3	79
Information about IAQ provided on your website	4	78
Other (please indicate below)		

Further comments

Education and Resources

Please indicate the value you place on educating the following population about improving indoor air quality (IAQ)

Value -	None	Low	Indifferent	Reasonable	Significant
Building Designers/Architects	0	0	0	23	59
Building Maintenance/Engineers/HVAC	0	4	1	54	23
Environmental Health Officers	1	2	54	14	11
Health, Safety, Environmental Practitioners	0	1	67	4	10
Housing Officers	1	5	64	3	9
General Public	2	0	77	2	1
Other (please indicate below)					

Please indicate the value you place on the following resources to assist with managing indoor air quality (IAQ)

Value -	None	Low	Indifferent	Reasonable	Significant
Free information website for public and LA (similar to HSE)	0	0	1	8	73
IAQ toolkits for commercial businesses	0	0	4	3	75
IAQ toolkit for housing (private and social)	0	1	11	13	57
IAQ investigation kits for LA to identify route causes	0	2	0	3	77
Clear standards to measure against	0	0	0	1	81
Improvement in education (degree programmes)	0	0	1	3	78
Independent organisation championing IAQ matters	1	1	0	1	79
Other (please indicate below)					

What value would you place on delivering IAQ within an education programme

Value -	None	Low	Indifferent	Reasonable	Significant
Via continuous professional development (CPD) courses	0	3	2	56	21
HE (incorporated into existing degree programmes)	0	1	3	51	27
Other (please indicate below)	81	0	1	0	0

Further comments

Further comments

Any overarching issues not highlighted within questionnaire you wish to be taken into consideration

Following the recent Lord Young's report regarding common sense health and safety, how do you believe this report will impact prioritises within your organisation?
http://www.number10.gov.uk/news/latest-news/2010/10/lord-young-report-55605

Will there be any increases/decreases of health with regards to changing prioritises? How will this impact IAQ?

Any further comments

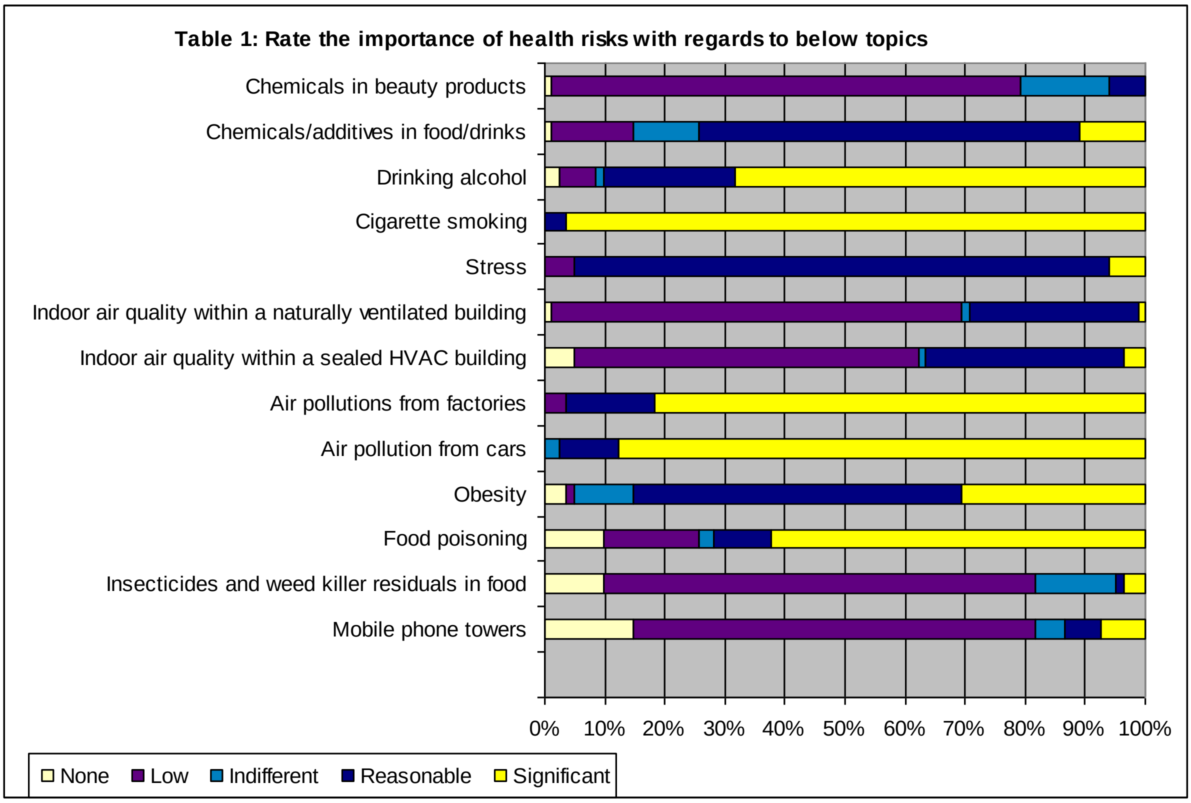
Thank you for your time and cooperation
Please send this file to **Email address removed for publication**

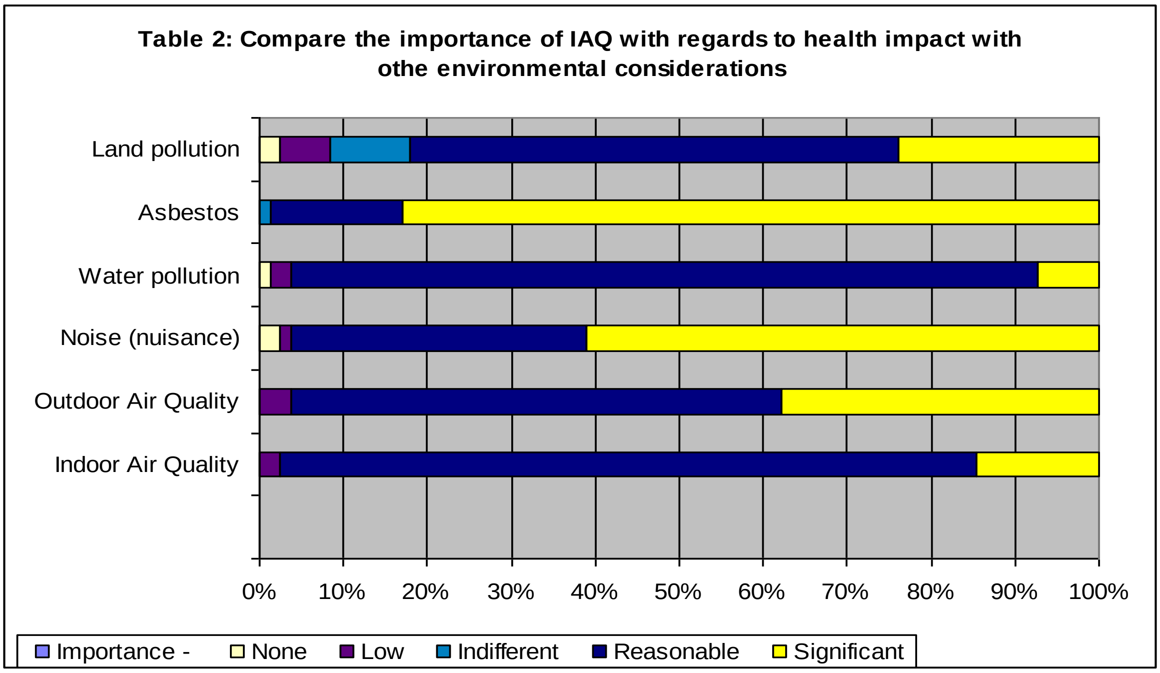
Any further comments (please also feel free to send any detailed comments under a separate e-mail to **Email address removed for publication**

Further details are available from the IAQUK website: www.iaquk.org.uk IAQUK

Appendix 5 - Results from IAQ Survey sent to local authorities

Significance of Indoor Air Quality (IAQ)





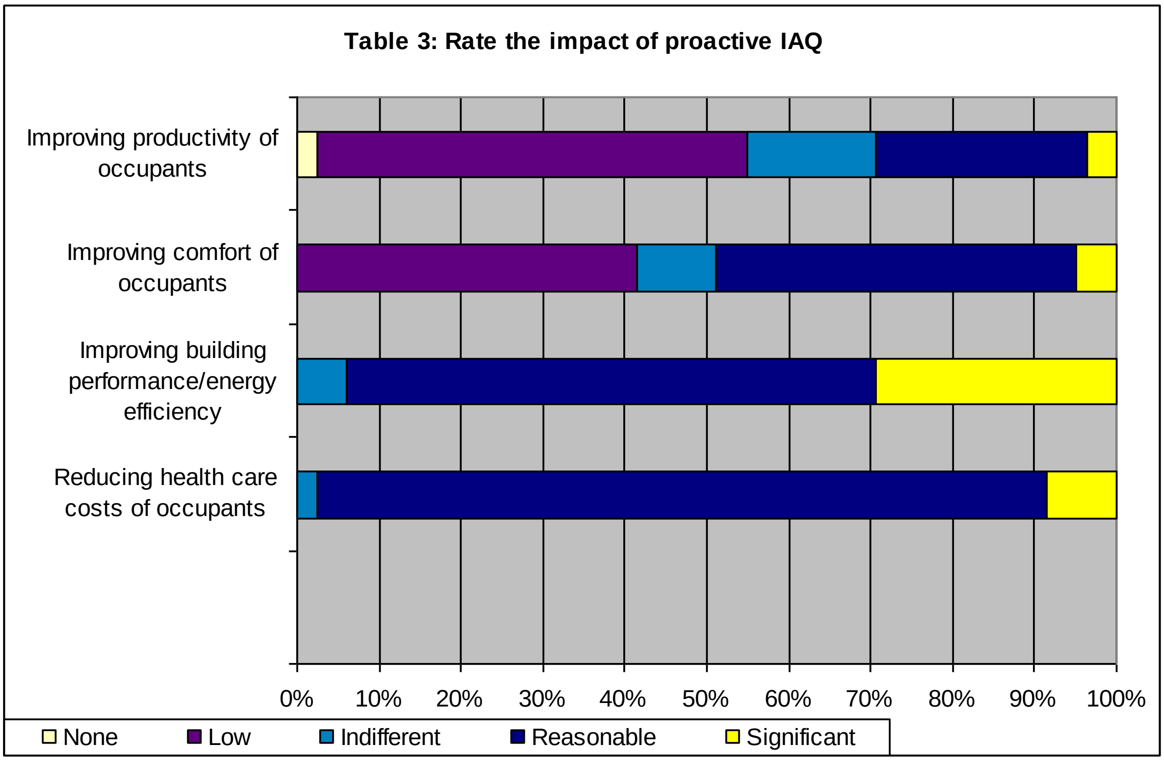


Table 3: Rate the impact of proactive IAQ
Improving productivity of occupants
Improving comfort of occupants
Improving building performance/energy efficiency
Reducing health care costs of occupants
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
None
Low
Indifferent
Reasonable
Significant

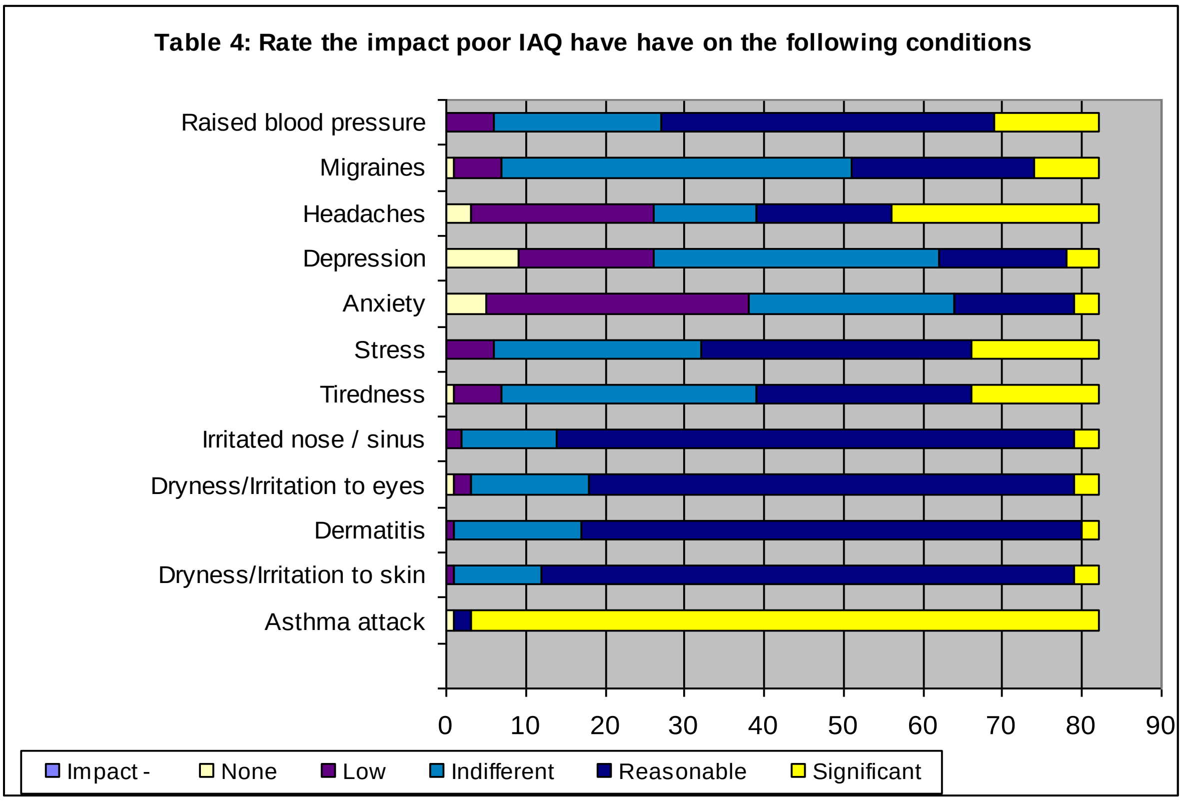
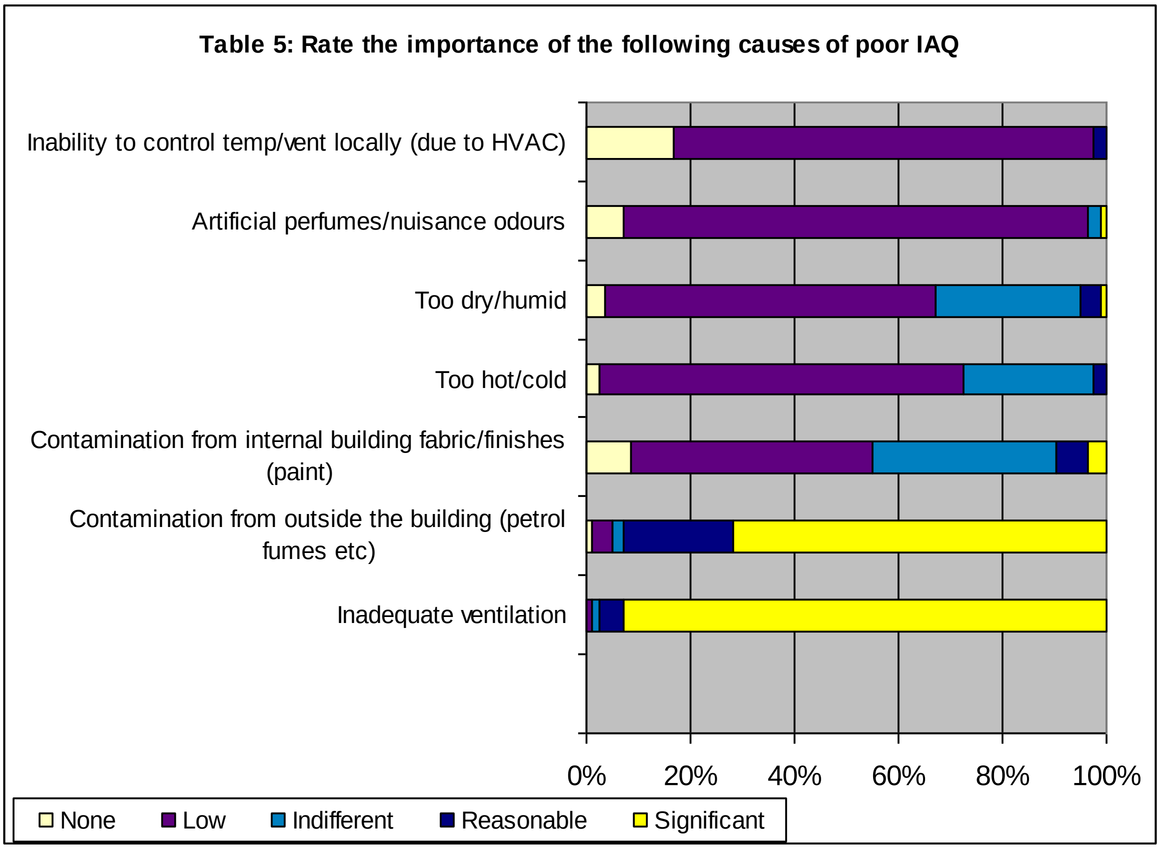


Table 4: Rate the impact poor IAQ have have on the following conditions
Raised blood pressure
Migraines
Headaches
Depression
Anxiety
Stress
Tiredness
Irritated nose / sinus
Dryness/Irritation to eyes
Dermatitis
Dryness/Irritation to skin
Asthma attack
0
10
20
30
40
50
60
70
80
90
Impact -
None
Low
Indifferent
Reasonable
Significant



Management of Indoor Air Quality (IAQ)

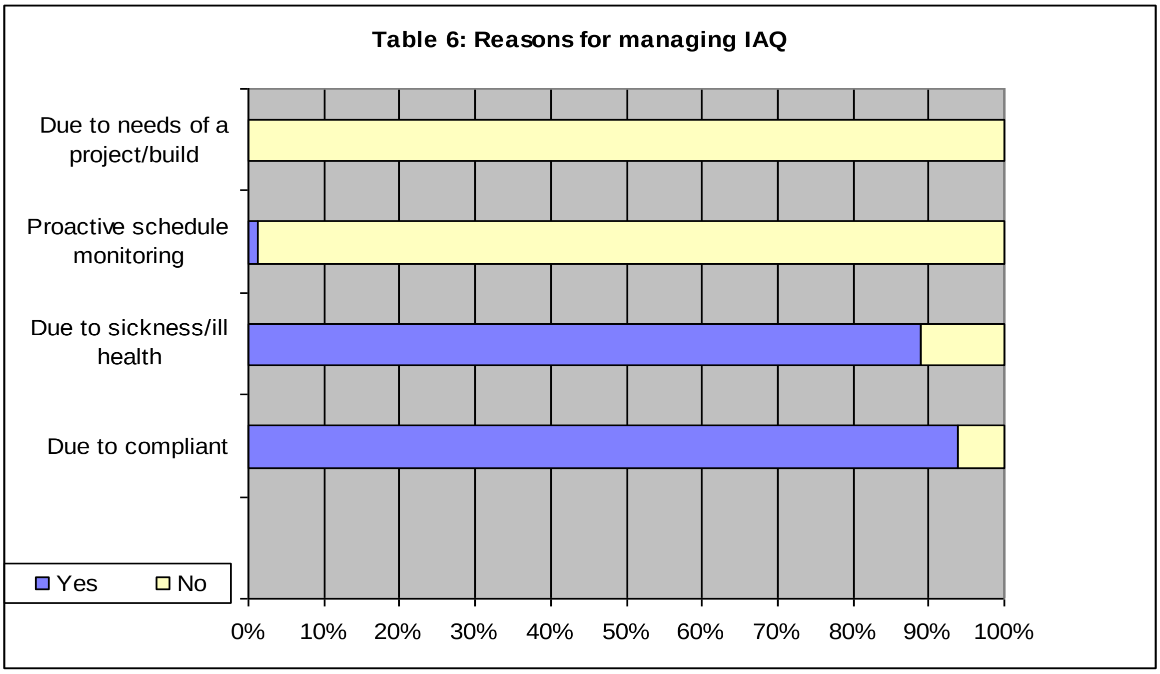


Table 7: Reasons for monitoring outdoor air quality

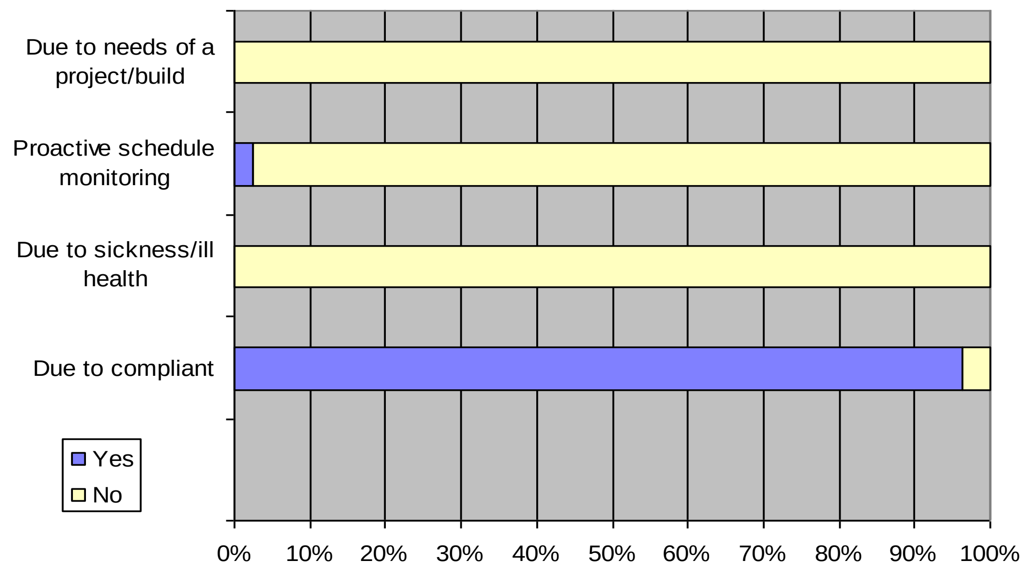
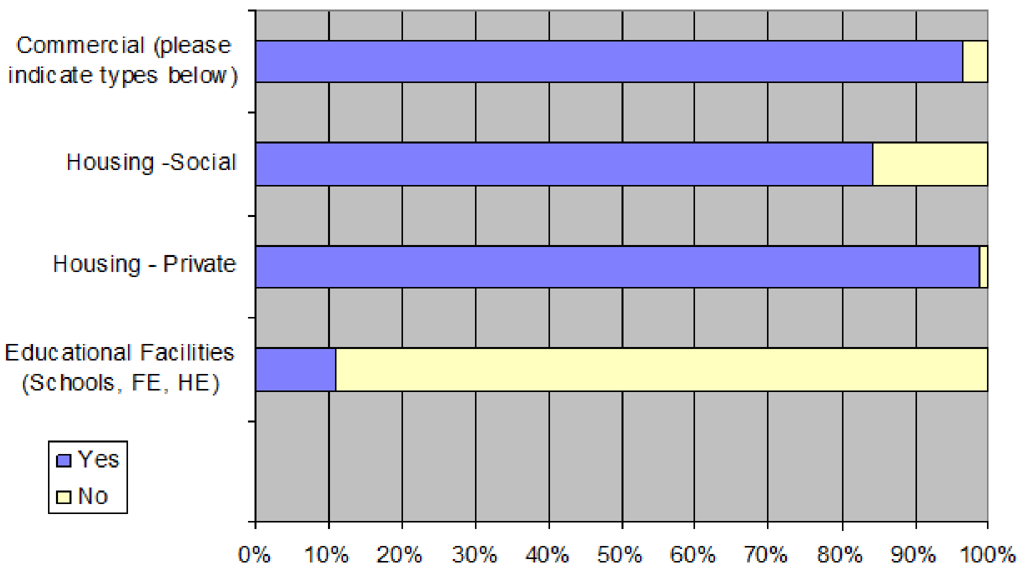


Table 8: Which % of sources generate complaints regarding IAQ



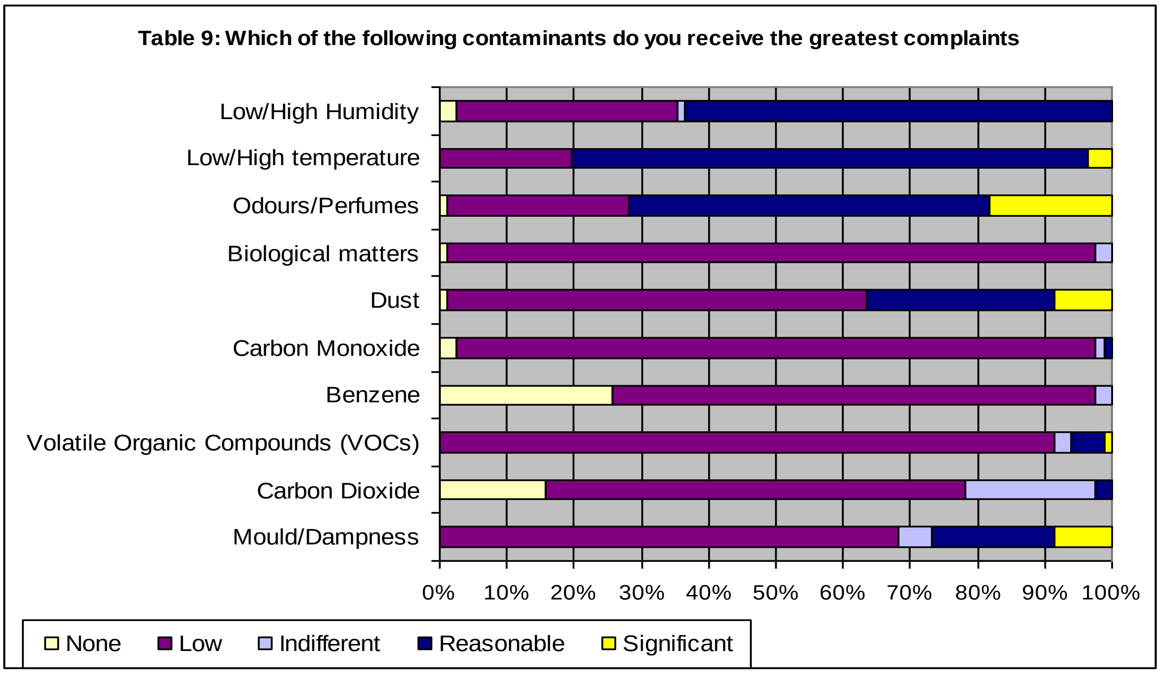


Table 9: Which of the following contaminants do you receive the greatest complaints
Low/High Humidity
Low/High temperature
Odours/Perfumes
Biological matters
Dust
Carbon Monoxide
Benzene
Volatile Organic Compounds (VOCs)
Carbon Dioxide
Mould/Dampness
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
None
Low
Indifferent
Reasonable
Significant

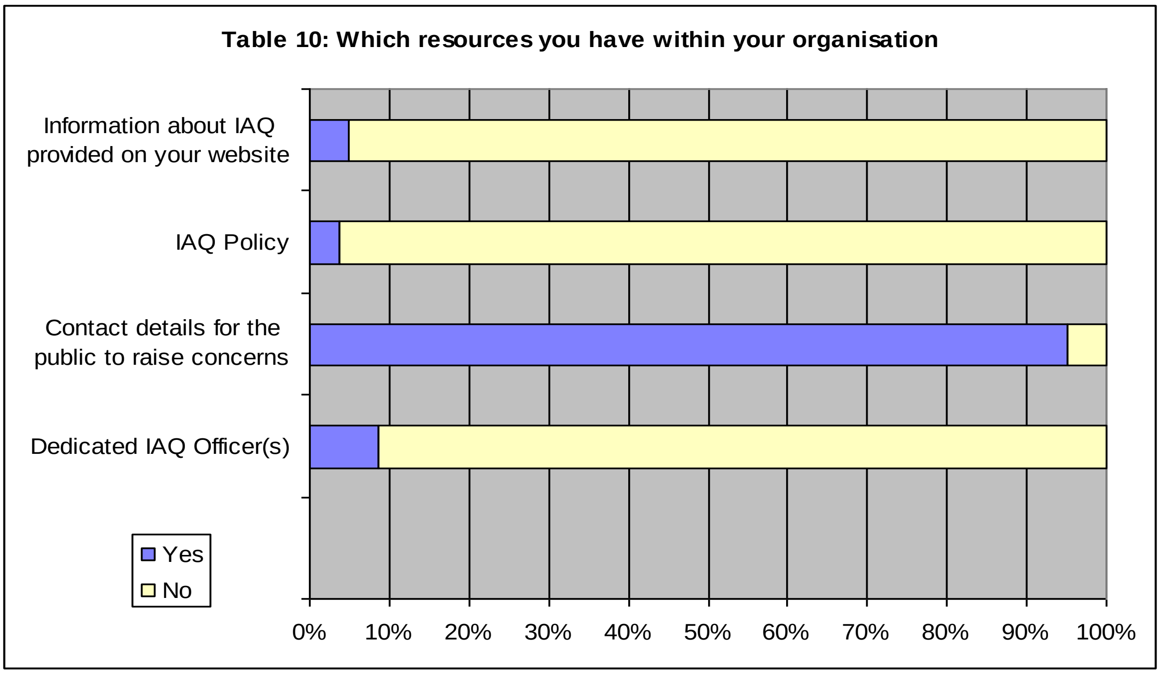


Table 10: Which resources you have within your organisation
Information about IAQ provided on your website
IAQ Policy
Contact details for the public to raise concerns
Dedicated IAQ Officer(s)
Yes
No
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

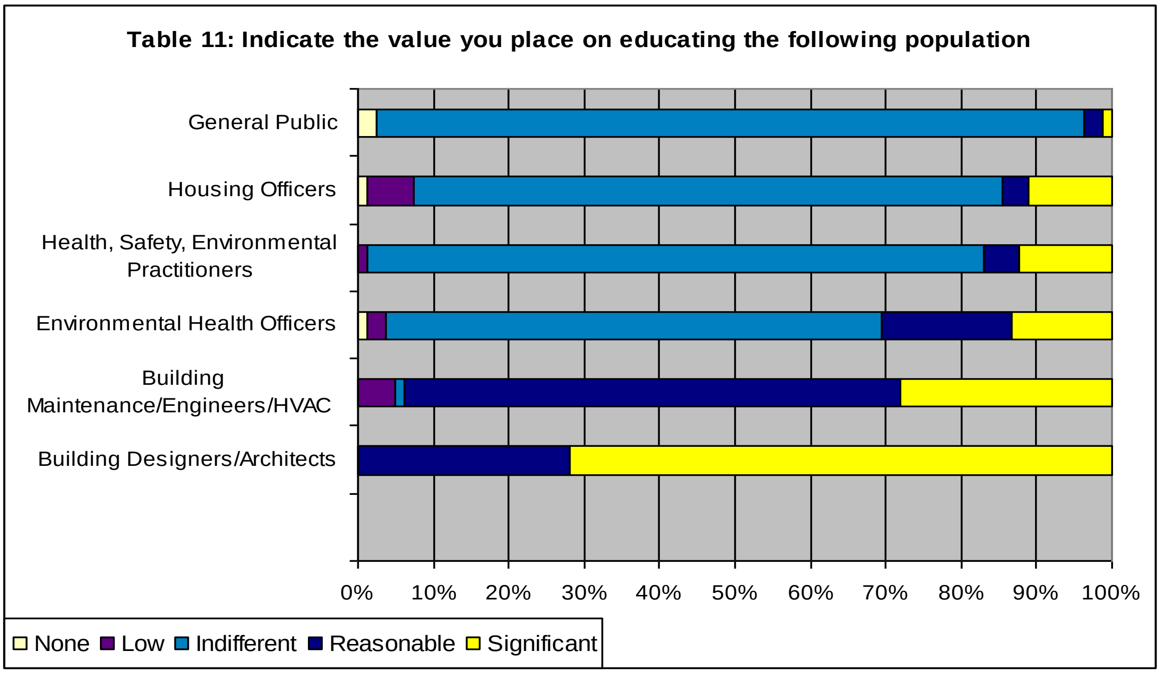


Table 11: Indicate the value you place on educating the following population
General Public
Housing Officers
Health, Safety, Environmental Practitioners
Environmental Health Officers
Building Maintenance/Engineers/HVAC
Building Designers/Architects
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
None
Low
Indifferent
Reasonable
Significant

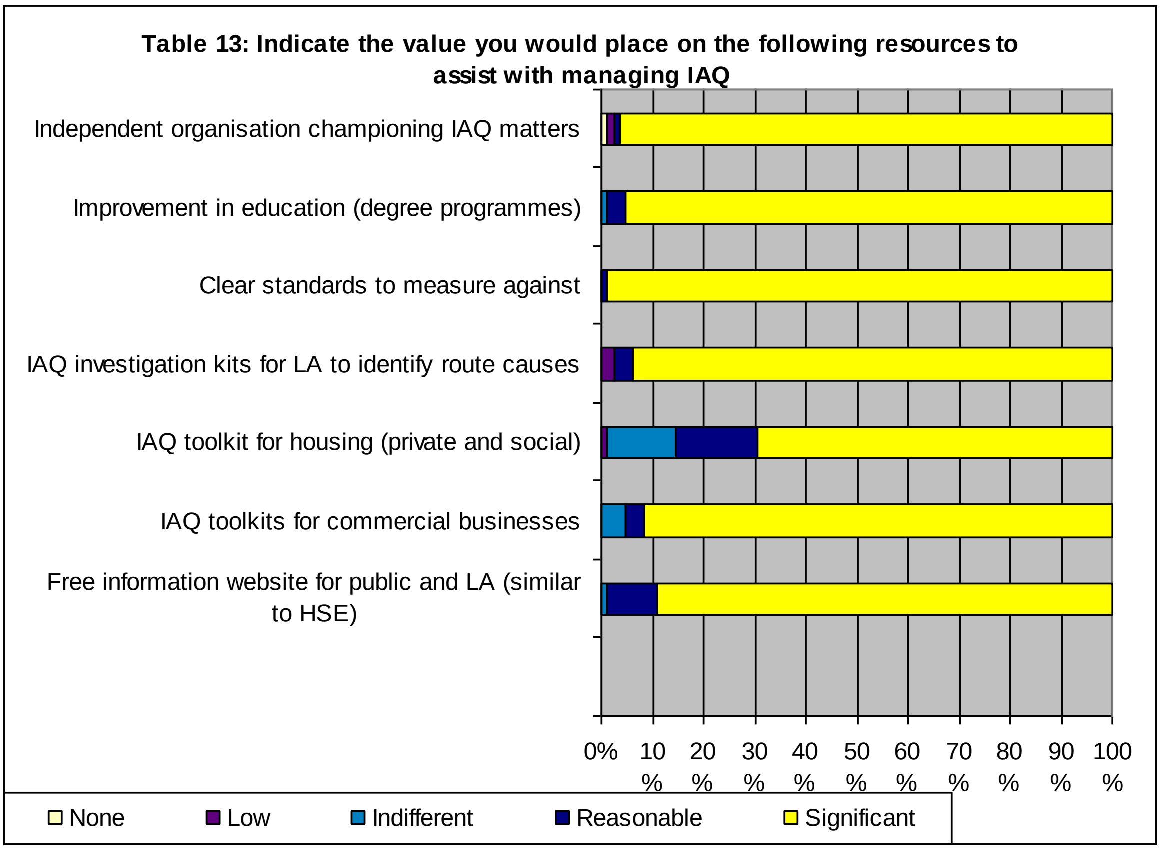
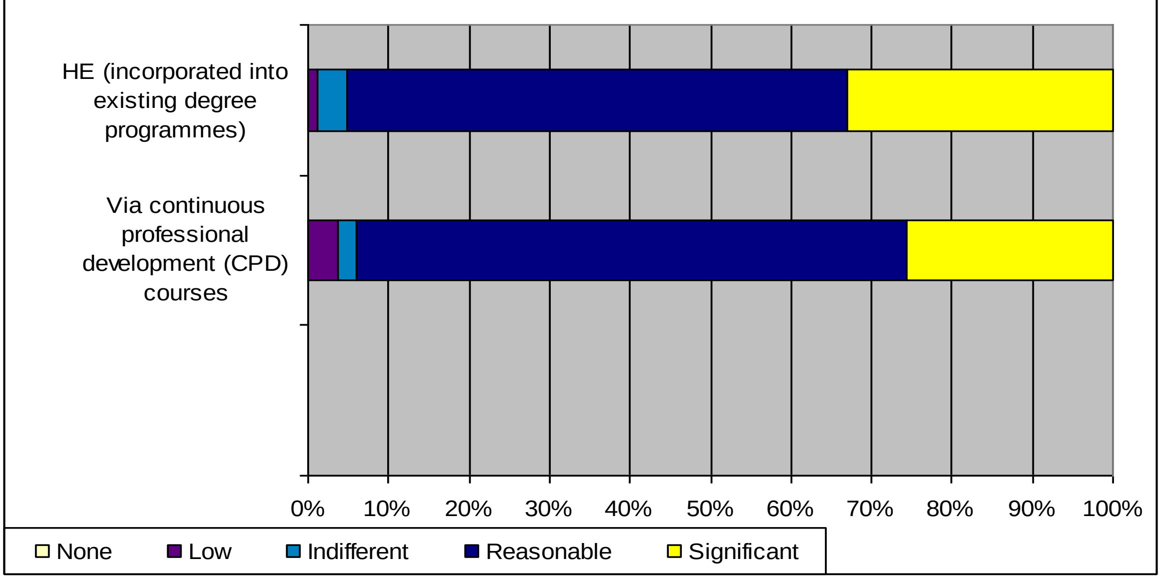


Table 13: Indicate the value you would place on the following resources to assist with managing IAQ
Independent organisation championing IAQ matters
Improvement in education (degree programmes)
Clear standards to measure against
IAQ investigation kits for LA to identify route causes
IAQ toolkit for housing (private and social)
IAQ toolkits for commercial businesses
Free information website for public and LA (similar to HSE)
0%
10 %
20 %
30 %
40 %
50 %
60 %
70 %
80 %
90 %
100 %
None
Low
Indifferent
Reasonable
Significant

Table 14: What value would be placed on the following education programmes

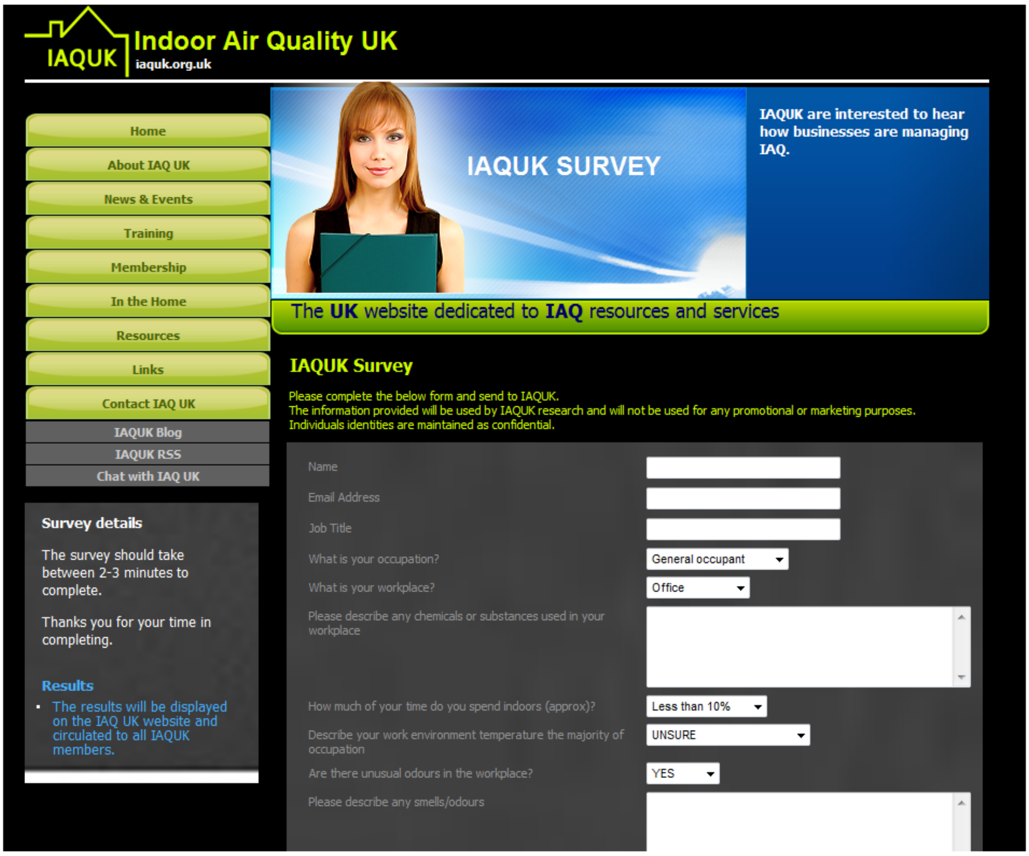


Appendix 6 – OHS practitioners IAQ survey and results

Online survey for OHS practitioners to complete.

No direct correspondence requesting participation.

Screen Shot from www.iaquk.org.uk



What is your occupation?		Health & Safety	CDM Coordinator	Admin	HR
	%	88	2.5	8	1.5
	Actual	147	5	13	3

Are the surveyors registered with any associations (hold ctrl key for multi-selection		IOSH	BOHS	Other	Blank
	%	100	1.8	20	0
	Actual	168	3	34	0

What is your workplace?		Office	Retail	Manufacturing	Engineer	Construction	Healthcare	Transport	Services	Agriculture	Education	Hospitality	Entertainment
	%	70	1	4	0	21	1	0	1	0	0.5	0.5	0
	Actual	117	2	7	0	36	2	0	2	0	1	1	0

How much of your time do you spend indoors (approx)?		<10%	10-25%	26-50%	51-75%	76-90%	>91%
	%	0	1	4	3	22	70
	Actual	0	2	7	5	36	118

Describe your work environment temperature the majority of occupation		Too Hot	Warm	Comfortable	Cold	Uncomfortable fluctuating
	%	3.5	25	5	10	56
	Actual	6	42	9	17	93

Are there unusual odours in the workplace?		Yes	No	Unsure
	%	32	54	14
	Actual	54	91	23

Describe the air		Too dry	Comfortable	Too humid	Unsure
	%	58	22	0.5	19.5
	Actual	97	37	1	33

Is your work area dusty?		Yes	No	Unsure
	%	13.5	86	0.5
	Actual	23	144	1

Do you get static shocks from electricity?		Yes	No	Unsure
	%	1	97	2
	Actual	2	163	3

Does the temperature vary from room to room?		Yes	No	Unsure
	%	90	6.5	3.5
	Actual	151	11	6

Does the temperature vary during the day?		Yes	No	Unsure
	%	93	5	2
	Actual	156	9	3

Are there drafts where you work?		Yes	No	Unsure
	%	26	55	18
	Actual	44	93	31

Do you feel more or less tied in the afternoon?		The Same	More	Less	Unsure
	%	23	66	3	8
	Actual	39	111	5	13

How much control do you have over your environment?		None	Some	Completely
	%	82	15	3
	Actual	139	25	4

Have you experienced any of the following symptoms, or have conditions become more acute, that you believe is attributed to indoor air quality?		Headache	Nausea	Dizziness	Tiredness	Irritation of eyes, nose, throat	Breathing problems	Coughing	Wheezing	Shortness of breath	Blurred vision	Sinus	Difficulty in concentration	Dry skin	Migraines	Panic attacks	Anxiety
	%	28	0.5	0	21	5	0.5	0.5	0.5	0	0	1	14	13	16	0	0
	Actual	86	2	0	63	13	1	2	2	0	0	3	41	38	48	0	0

On average how quickly do the symptoms appear once you are in your work area?		<1 hour	2-4 hours	> 4 hours	> 1 day	> 1 week	> 1 month	N/A
	%	23	10	49	2	0	0	16
	Actual	38	17	83	3	0	0	27

When do the symptoms go away?		<1 hour	2-4 hours	> 4 hours	> 1 day	> 1 week	> 1 month	N/A
	%	11	5	24	43	0	0	17
	Actual	19	9	41	72	0	0	27

Are you aware of other people suffering similar symptoms in your work area?		Yes	No	Unsure
	%	40	10	50
	Actual	67	17	84

How satisfied are you with your work environment's indoor air quality?		Not satisfied	Satisfied	Very satisfied
	%	70	23	7
	Actual	118	38	12

How old is your building?		<12 months	1-5 years	6-10 years	11-25 years	> 26 years	Unsure
	%	14	57	9	5	4	11
	Actual	23	95	15	9	7	19

Is the room naturally or mechanically ventilated?		Natural	Mechanical	Unsure
	%	12.5	84.5	3
	Actual	21	142	5

Do you have carpets of	Carpets	Hard flooring	Mix	Unsure

hard flooring?					
	%	79	7	13	1
	Actual	131	13	22	2

What is the layout of your work environment?		Open plan	Room 1-5 people	Room 6 -25 people
	%	57	16	27
	Actual	96	26	46

Does your company test the indoor air quality?		Yes	No	Unsure
	%	17	43	40
	Actual	29	72	67

If you company does test IAQ, who conducts the survey?		Internal	External	Both
	%	83	17	0
	Actual	24	5	0

Are IAQ problems acknowledged and managed efficiently?		Yes	No	Unsure
	%	11	54	35
	Actual	18	91	59

How important is indoor air quality to you?		High	Medium	Low	Unsure
	%	33	46	14	7
	Actual	57	77	23	11

Do you have access to resources to help you manage indoor air quality		Yes	No	Unsure	Not required
	%	2	92	2	4
	Actual	3	155	3	7

How much value do you place on educating people about indoor air quality?		High	Medium	Low	Unsure
	%	75	22	2	1
	Actual	126	37	3	2

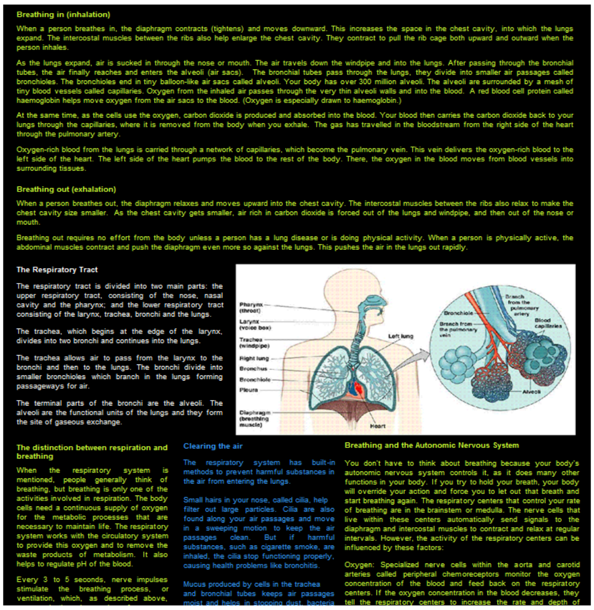
Appendix 7 - Screen shots from www.IAQUK.org.uk

Home page:

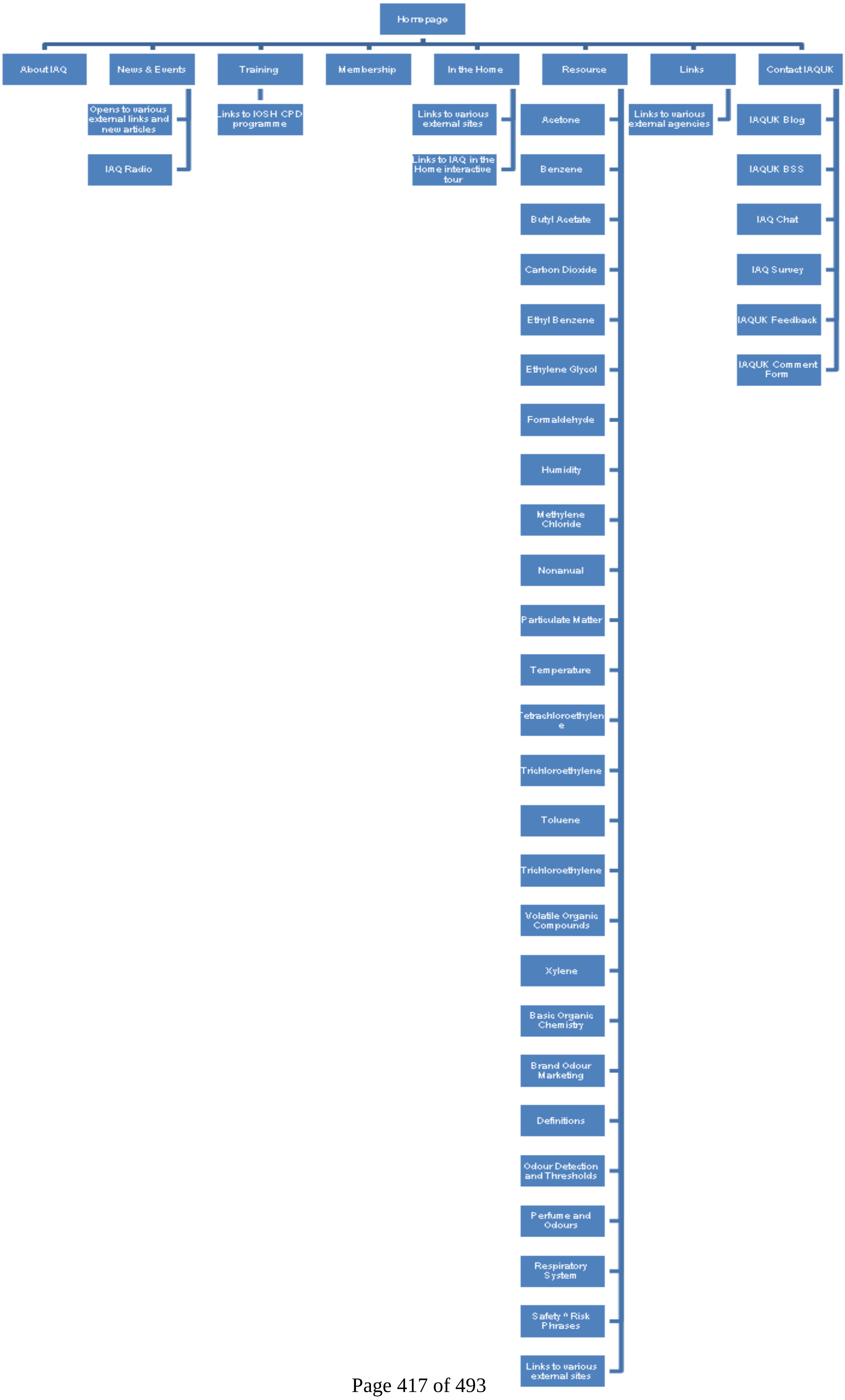
News & Events

Resources Page – Particulate Matter:

Resources Page - Respiratory System



Appendix 8 - Schematics from www.IAQUK.org.uk



Appendix 9- Principal chemicals found in scented products

Reference:
Ezendam, J., Te Biesebeek, J. D., and Wijnhoven, S. W. P. (2009). 'The presence of fragrance allergens in scented consumer products'. National institute for public Health and Environment: RIVM report, 340301002, 2009.

Fragrances	% in all scented products	% in scented car products	% in sprays	% in electrical room perfumes	% in scented candles
n =	*49*	*12*	*15*	*18*	*4*
D-limonene	69.4%	83.3%	46.7%	77.8%	75%
Linalool	69.4%	83.3%	40%	83.3%	75%
Geraniol	53.1%	66.7%	13.3%	77.8%	50%
Citronellol	49%	41.7%	20%	77.8%	0%
α-Isomethylionon	42.9%	50%	13.3%	72.2%	0%
Citral	36.7%	50%	6.7%	61.1%	0%
Eugenol	32.7%	41.7%	0%	50%	50%
Benzyl alcohol	26.5%	0%	0%	66.7%	25%
Coumarin	26.5%	33.3%	6.7%	38.9%	25%
Benzyl benzoate	24.5%	16.7%	0%	44.4%	50%
Benzyl salicylate	22.4%	8.3%	13.3%	38.9%	25%
Hydroxycitronellal	20.4%	16.7%	6.7%	33.3%	25%
Lillial*	16.3%	8.3%	0%	38.9%	0%
Hexyl cinnamal	16.3%	0%	20%	27.8%	0%
Lyral*	16.3%	16.7%	0%	27.8%	25%
Cinnamyl alcohol	10.2%	8.3%	0%	22.2%	0%
Cinnamal	8.2%	8.3%	0%	11.1%	25%
Isoeugenol	6.1%	0%	0%	16.7%	0%
Amyl cinnamal	2.0%	0%	0%	11.1%	0%
Farnesol	2%	0%	0%	5.5%	0%
Anisyl alcohol	0%	0%	0%	0%	0%
Amyl cinnamyl alcohol	0%	0%	0%	0%	0%
Benzyl cinnamate	0%	0%	0%	0%	0%
Methyl heptine carbonate	0%	0%	0%	0%	0%
Oak moss	0%	0%	0%	0%	0%
Tree moss	0%	0%	0%	0%	0%

Appendix 10 - Exposure Limits

References The Royal Society of Chemistry, "Chemical Safety Data Sheets" Volumes 1 and 5.

Compound	Mg/m³	ppm	Compound	Mg/m³	ppm
Acetic acid	0.043	0.016	2-Hydroxyethyl acetate	0.527	0.114
Acetic anhydride	0.0013	0.00029	Light fuel oil	0.053	
Acetone	13.9	4.58	3-Methylbutanal	0.0016	0.0004
Acrylic acid	0.0013	0.0004	2-Methyl-1-butanol	0.16	0.041
Amyl acetate	0.95	0.163	Methyldithiomethane	0.0011	0.00026
iso Amyl acetate	0.022	0.0038	2-Methyl 5-ethyl pyridine	0.032	0.006
Benzene	32.5	8.65	Methyl methacrylate	0.38	0.085
1,3-Butadiene	1.1	0.455	3-Methoxybutyl acetate	0.044	0.007
1-Butanol	0.09	0.03	1-Methoxypropan-2-ol	0.0122	0.003
2-Butanol	3.3	1	1-Methoxy-2-propylacetate	0.0075	0.0014
2-Butanone (MEK)	0.87	0.27	2-Methyl-1-pentanol	0.096	0.021
Butoxybutane	0.03	0.005	2-Methyl pentaldehyde	0.09	0.02
2-Butoxyethanol	0.0051	0.00097	4-Methyl-2-pentanone (MIBK)	0.54	0.121
2-Butoxyethyl acetate	0.045	0.0063	2-Methyl-2-propanol	71	21.46
Butoxypropanol	0.191	0.0324	α-Methyl styrene	0.021	0.003
Butyl acetate	0.047	0.0066	1-Nitropropane	28.2	7.09

2-(2-Butoxyethocy)ethanol	0.0092	0.0013	1-Octene	0.33	0.066
2,2-butoxyethoxyethyl acetate	0.015	0.0016	2-Octene	0.5	0.1
Carbon tetrachloride	280	40.73	2-Octyne	0.03	0.006
Carbon sulphide	0.0275	0.0102	2,4-Pentanedione	0.045	0.01
m-Cresol	0.0013	0.0003	1-Pentanol	0.02	0.0051
o-Cresol	0.0028	0.0005	Petroleum naptha	0.2	
p-Cresol	0.0029	0.0006	Phenyl ether	0.0021	0.0003
Cyclohexane	315	83.8	2-Picoline	0.014	0.0034
Cyclohexanone	0.083	0.019	Propanal	0.014	0.0054
Dichloromethane	3.42	0.912	2-Propanol	1.185	0.442
Diesel	0.06	2-Propen-1-ol	1.2	0.47	
Dimethyl adipate	7.101	0.913	iso Propylamine	0.158	0.06
Dimethyl glutarate	1.212	0.169	Propylbenzene	0.048	0.009
Dimethyl succinate	0.992	0.152	Propylene-n-butylether	0.206	0.01
1,4-Dioxane	30.6	7.78	Propyl ether	0.024	0.0053
1,3-Dioxolane	56.3	17.02	Styrene	0.16	0.0344

Diphenylmethane	0.41	0.55	1,1,2,2-Tetrachloroethane	1.6	0.21
Ethoxypropanol	0.161	0.035	Toluene	0.644	0.16
Ethoxypropyl acetate	0.0052	0.0008	Trichloroethylene	8	1.36
Ethyl acetate	2.41	0.61	Trimethylamine	0.0026	0.001
Ethyl alcohol	0.28	0.136	Xylene (mixed)	0.078	0.016
2-Ethyl-1-butanol	0.07	0.015	2,3 Xylenol	0.0037	0.0007
2-Ethyl-1-hexanol	0.5	0.086	2,4 Xylenol	0.064	0.0117
2-Ethylhexyl acrylate	0.6	0.073			
2-Furaldehyde	0.25	0.058			
1-Hexanol	0.005	0.0011			
Hydrogen sulphide	0.00076	0.0005			

Appendix 11 - IOSH CPD IAQ Syllabus

Learning Outcomes

- Outline the scope and nature of indoor air quality;
- Explain the benefits of good IAQ and the consequences of poor IAQ;
- Describe the types and components of ventilation systems;
- Outline the process for investigating IAQ complaints;
- Identify the sources of contamination /preventive measures to adopt;
- Describe techniques and methodology for surveying and monitoring;
- Conduct risk assessments of IAQ.

Element One – Scope and nature of indoor air quality

- An overview of indoor air quality (IAQ);
- IAQ in the news;
- Understanding the difference between SBS and BRI;
- Legislation and guidance.

Element Two - Consequences of Poor IAQ

- Human health effects (physical and psychological);
- How the human respiratory system works;
- Different parts of the respiratory zone;
- Circulation and gas exchange;
- Pollution sensitivities;
- Respiratory diseases;
- Comfort and productivity;
- Financial costs;
- Building conservation;
- Building design and fabric;
- Building maintenance;
- Space and work activities.

Element Three - Ventilation

- Different types and components of ventilation systems;
- Velocity and volume;
- Recommended air supply rates;
- Ventilation for different activities;
- Mechanical versus natural ventilation.

Element Four – Fundamental components of IAQ

- Understanding temperature;
- Understanding humidity;
- Understanding carbon dioxide;
- (Each section to explore composition about the component, such as source, health risks, comfort factors and influence on population).

Element Five - Types of pollutions

Divided into organic and inorganic pollutants, physical pollutants, naturally occurring pollutants and biological - (VOCs, Molds, allergens, dusts/fibres):

- Details/composition about the substance;
- Source of pollutant;
- Methods to measure;
- Health risks, comfort factors and influence on population;
- Effective control measures.

Element Six – Investigating IAQ concerns

- Investigating complaints;
- Exploring exposure and health effects;
- Occupational health support.

Element Seven - Proactive IAQ management

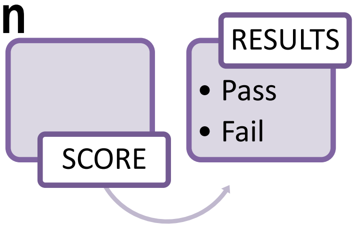
- Management strategy and policy;
- Surveying and monitoring;
- Types of surveys and accredited standards;
- Sampling and inspection methodology;
- Collating data, sample sizes, data logging;
- Types of instruments for measuring IAQ;
- Analysing data;
- Risk assessing;
- Introduction to risk assessments, hazard identification and weighting of risk factors;
- Calculating exposures;
- EH40 standards.

Element Eight - Communication

- Structure for reporting findings;
- Protocol for communicating risk;
- Risk perception;
- IAQ - the business case.

Appendix 12 - IOSH CPD IAQ Questionnaire (with answers)

Indoor Air Quality Course Examination



Name:
Date:
Tutor:

- Please answer all below questions (1-12) within given timescale of 45 minutes
- There are 50 marks in total and a 70% pass mark is required for success completion of this course.
- Please use additional paper where required
- When complete please check your answers prior to returning completed questionnaire to the tutor.

---

1. (a) Describe the difference between sick building syndrome and building related illness?
(4 marks)
(b) Describe the symptoms and illness of each SBS and BRI? (4 marks)

SICK BUILDING SYNDROME

- Persistent set of symptoms
- Symptoms relieved after exiting building

Predominantly non-specific symptoms

- Eye, nose, throat irritation
- Sensation of dry mucous membranes and skin
- Erythema (redness of the skin)
- Mental fatigue
- Headache
- High frequency of airway infection or cough
- Nausea and dizziness

- Affecting 20% or more of building occupants
- Symptoms relieve upon exiting the building

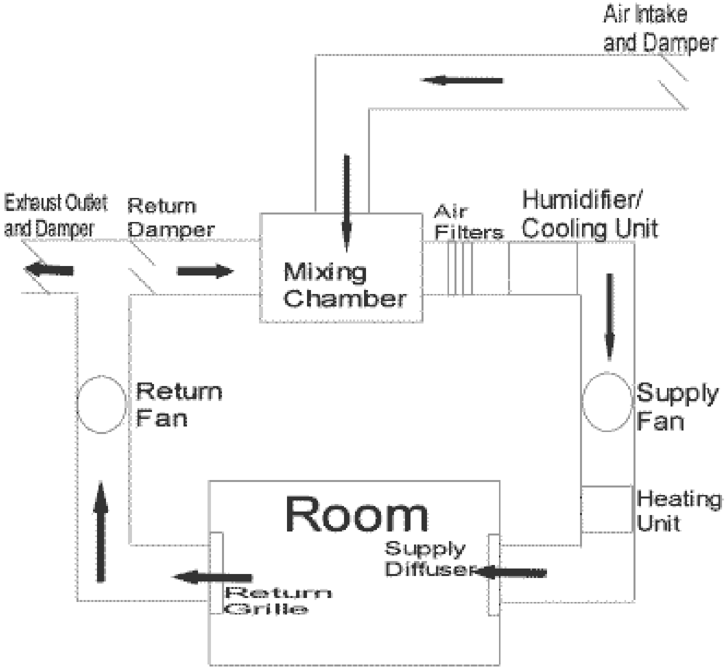
BUILDING RELATED ILLNESS

- Clinically recognised disease

Specific contaminant source causing specific clinical syndrome

- Pontiac Fever
- Legionnaire's Disease
- Asthma
- Allergy
- Respiratory Disease
- Only afflicts a few occupants
- Not alleviate by exiting the building

2. Sketch with labels the basic components of mechanical ventilation system (8 marks)



- Blower
- Heating/cooling elements
- Filters
- Mixing chambers
- Supply/return
- Dampers
- Ductwork
- Fans

3. What are the benefits of ventilation within a building? (3 marks)

- Comfort ventilation
- Reduces odours
- Improves thermal comfort

- Health ventilation
- Dilutes air contaminants
- Provides "fresh" air

- Structural cooling
- Maintains integrity of building envelope and building components.

4. What would you check on a HVAC system? (6 marks)

- Outdoor air intake
- Outdoor/return/exhaust air
- Filters
- Heating and cooling coils
- Supply air fan
- Humidifier
- Ductwork

5. List two types of defences the body uses to reduce pollutants entering your body? (2 marks)

- Cough/sneeze reflex
- Mucus
- Nose hairs
- Ciliary escalator
- Macrophages

6. What makes thermal comfort subject? (3 marks)

Examples included from:

- Individuals
- Work Space
- Environment

7. List five types of products would you find benzene in? (5 marks)

Products that contain benzene include paint, varnishes, solvents, detergents, thinners, inks, rubbers, pesticides, dyes, lubricants, decreasing products and even medication such as paracetamol. It is also used in dry cleaning, petroleum processing, rubber tyre manufacturing, forms of rubber and plastic manufacturing such as shoes. It is also created as an emission from vehicle and smoking.

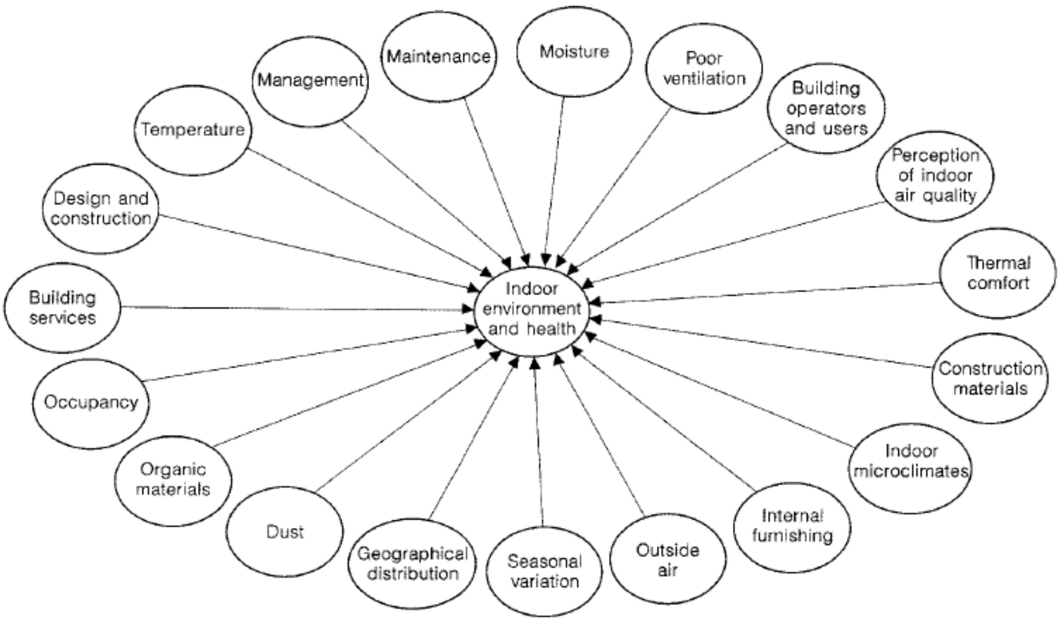
8. What are the health effects from exposure to formaldehyde? (4 marks)

- Short term health effects often initially display as irritation to the nose, throat and eyes. Individuals may also complain of headaches or feeling of nausea, even breathlessness has been associated.
- Long term exposure can cause a decrease of the lung function capacity.
- Because formaldehyde is a hardening agent, it can cause similar effects to the skin.
- Formaldehyde is a sensitising agent to the skin and respiratory system.
- Menstrual and thyroid irregularities, the impairing of cognitive functions including memory and concentration and contributing to sleep disturbances have been recognised as potential symptoms.
- Existing health (asthma) and lifestyle habits such as smoking, which contains high concentrates of formaldehyde, will also influence exposure responses

9. List two types of virus within an indoor environment? (2marks)

- Smallpox
- Influenza
- Chicken pox
- Adenovirus 4 and 7
- Measles
- Coxsackie A21
- Rubella
- Lymphocytic choriomeningitis

10. Mindmap the different variations to consider when evaluating indoor air quality? (4 marks)



11. List three types of sampling equipment? (3 marks)

- Stain tube detectors
- Dust monitoring equipment (inhalable/respiratory)
- Photoionization Detector (PID**)**
- Passive samplers
- Bag Sampling

12. What two concentration expressions are used when calculating workplace exposure limits? (2 marks)

- Milligram per Cubic meter - mg/m^3 for solids
- Parts per million (ppm) for gases

50 marks
70% for pass rate

Appendix 13 - IOSH CPD IAQ Training Syllabus

Indoor air quality

Find out how to manage indoor air quality and create a healthy, comfortable and productive working environment

Before the course
A basic understanding of COSHH would be beneficial but isn't essential.

Programme
Scope and nature of indoor air quality

Consequences of poor indoor air quality
- Human health effects (physical and psychological)
- Comfort and productivity

Different types and components of ventilation systems

Fundamental components of indoor air quality
- Understanding temperature, humidity and carbon dioxide

Types of pollution
- Sources of organic and inorganic pollutants, physical pollutants, naturally occurring pollutants and biological pollutants (volatile organic compounds, moulds, allergens, dusts/fibres)

Investigating indoor air quality concerns
- Surveying and monitoring

Proactive air quality management
- Management strategy and policy
- Risk perception
- The business case

Who'll benefit
Health and safety professionals, occupational health staff, occupational hygienists and managers with building responsibilities.

What you'll learn
After the course, you'll:
- appreciate the scope and nature of indoor air quality
- understand the benefits of good indoor air quality and the consequences of poor air quality
- be able to investigate quality concerns
- have a practical insight into surveying and risk assessing air quality matters
- understand the different control measures for creating a healthy, productive and comfortable environment

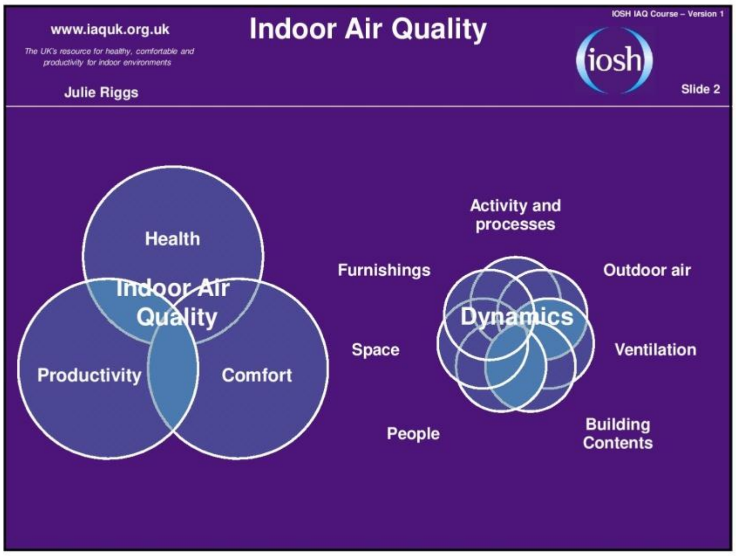
Tutor	Dates	Duration	References	Fees
Julie Riggs	21 March 2013 26 November 2013	one day	CPDI104/141083 CPDI104/141084	IOSH members £234 (£195+£39 VAT) Non-members £294 (£245+£49 VAT)

All our courses can be run in-house – if you're interested in on-site training for your team, contact +44 (0)116 257 3197 or bookings@iosh.co.uk for more information

Appendix 14 - IOSH CPD IAQ Training Slides

Please also see attached CD

1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Slide 2
Health
Indoor Air Quality
Productivity
Comfort
Activity and processes
Furnishings
Outdoor air
Dynamics
Space
Ventilation
People
Building Contents


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Slide 3
Contents
1. Scope and Nature of indoor air quality (IAQ)
2. Consequences of Poor IAQ
3. Ventilation
4. Fundamental Components of IAQ
5. Types of Pollutions
6. Investigating IAQ Concerns
7. Proactive IAQ Management


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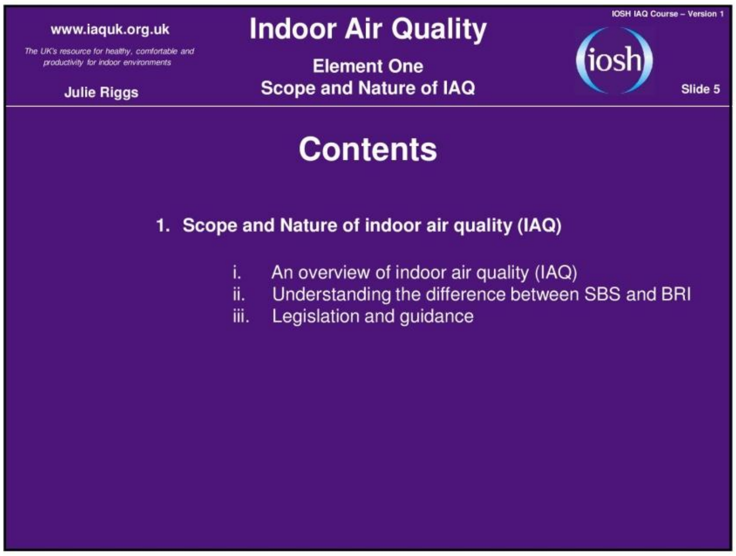
Slide 4
EP
PETROL
OPEN
Castrol
1. Scope and Nature of indoor air quality (IAQ)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Contents
1. Scope and Nature of indoor air quality (IAQ)
i. An overview of indoor air quality (IAQ)
ii. Understanding the difference between SBS and BRI
iii. Legislation and guidance

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Slide 6
An overview of indoor air quality (IAQ)
Indoor Air Quality (IAQ) refers to the physical, chemical, and biological characteristics of air in the indoor environment within a building and how it relates to the occupants physical and psychological health, comfort and productivity.
Three basic requirements for human occupancy:
• Thermal acceptability
• Maintenance of normal concentrations of respiratory gases
• Dilution and removal of contaminants to levels below health or odour discomfort thresholds


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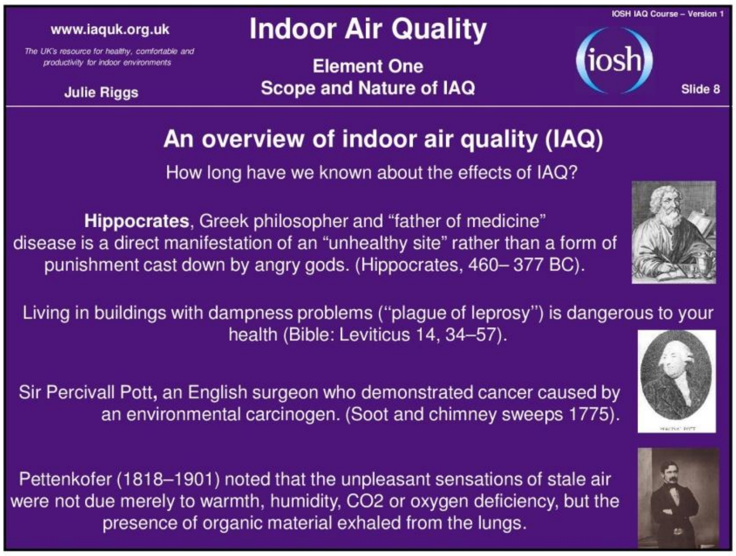
An overview of indoor air quality (IAQ)
• We spend 90% of our time indoors
• There are 10 times more pollutants indoors than in outdoor air
• EPA recognise IAQ as one of the top 5 health hazards
• According to the American Medical Association, 50% of all illnesses are caused or aggravated by polluted indoor air
• Changes in building design and work practices
• Multi-dimensional causes for poor IAQ

4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An overview of indoor air quality (IAQ)
How long have we known about the effects of IAQ?
Hippocrates, Greek philosopher and "father of medicine"
disease is a direct manifestation of an "unhealthy site" rather than a form of punishment cast down by angry gods. (Hippocrates, 460– 377 BC).
Living in buildings with dampness problems ("plague of leprosy") is dangerous to your health (Bible: Leviticus 14, 34–57).
Sir Percivall Pott, an English surgeon who demonstrated cancer caused by an environmental carcinogen. (Soot and chimney sweeps 1775).
Pettenkofer (1818–1901) noted that the unpleasant sensations of stale air were not due merely to warmth, humidity, CO2 or oxygen deficiency, but the presence of organic material exhaled from the lungs.


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An overview of indoor air quality (IAQ)
How long have we known about the effects of IAQ?
Energy Conservation
The "oil crisis" in 1973 forced the development of energy conserving strategies in a variety of industries.
For the building construction industry, emphasis was placed on energy efficiency through "airtightness". Air-tight enclosures reduce fresh air which can lead to the build-up of indoor air contaminants.
Therefore, the implementation of energy conserving strategies in the built form must be balanced with occupant health.

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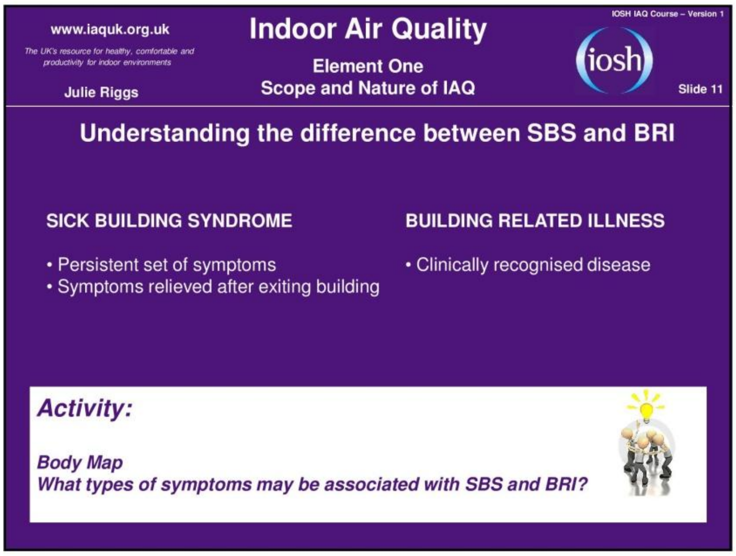
An overview of indoor air quality (IAQ)
There are fundamental developments in the last 45 years.
• The increase in the amount of time spent in indoor environments;
• The increased dependence on artificial products;
• Increase occupancy densities;
• Energy conservation techniques.
Work 40%
Residence 50%
Transport 6%
Outdoors 4%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Understanding the difference between SBS and BRI
SICK BUILDING SYNDROME
• Persistent set of symptoms
• Symptoms relieved after exiting building
BUILDING RELATED ILLNESS
• Clinically recognised disease
Activity:
Body Map
What types of symptoms may be associated with SBS and BRI?

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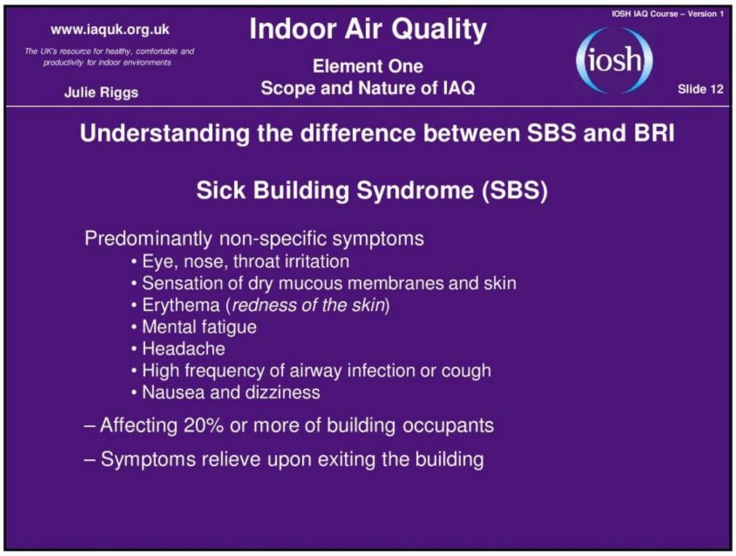
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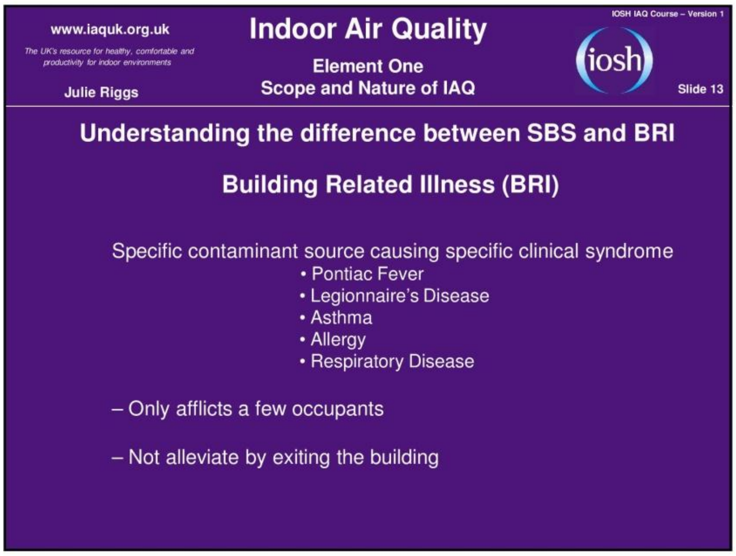
Understanding the difference between SBS and BRI
Sick Building Syndrome (SBS)
Predominantly non-specific symptoms
• Eye, nose, throat irritation
• Sensation of dry mucous membranes and skin
• Erythema (*redness of the skin*)
• Mental fatigue
• Headache
• High frequency of airway infection or cough
• Nausea and dizziness
– Affecting 20% or more of building occupants
– Symptoms relieve upon exiting the building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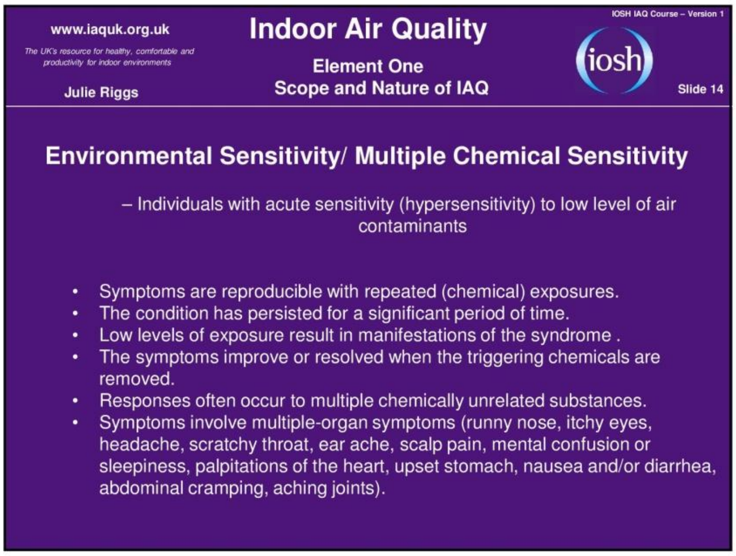
Understanding the difference between SBS and BRI
Building Related Illness (BRI)
Specific contaminant source causing specific clinical syndrome
• Pontiac Fever
• Legionnaire's Disease
• Asthma
• Allergy
• Respiratory Disease
– Only afflicts a few occupants
– Not alleviate by exiting the building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Slide 14
Environmental Sensitivity/ Multiple Chemical Sensitivity
– Individuals with acute sensitivity (hypersensitivity) to low level of air contaminants
• Symptoms are reproducible with repeated (chemical) exposures.
• The condition has persisted for a significant period of time.
• Low levels of exposure result in manifestations of the syndrome .
• The symptoms improve or resolved when the triggering chemicals are removed.
• Responses often occur to multiple chemically unrelated substances.
• Symptoms involve multiple-organ symptoms (runny nose, itchy eyes, headache, scratchy throat, ear ache, scalp pain, mental confusion or sleepiness, palpitations of the heart, upset stomach, nausea and/or diarrhea, abdominal cramping, aching joints).


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Legislation and Guidance
Building Regulations - Approved Document F: Means of Ventilation
Workplace (Health, Safety and Welfare) Regulations 1992
Control of Substances Hazardous to Health Regulations 2002
EH40 - Occupational Exposure Limits
The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) 1975 standards
WHO - Indoor Air Quality Guidelines

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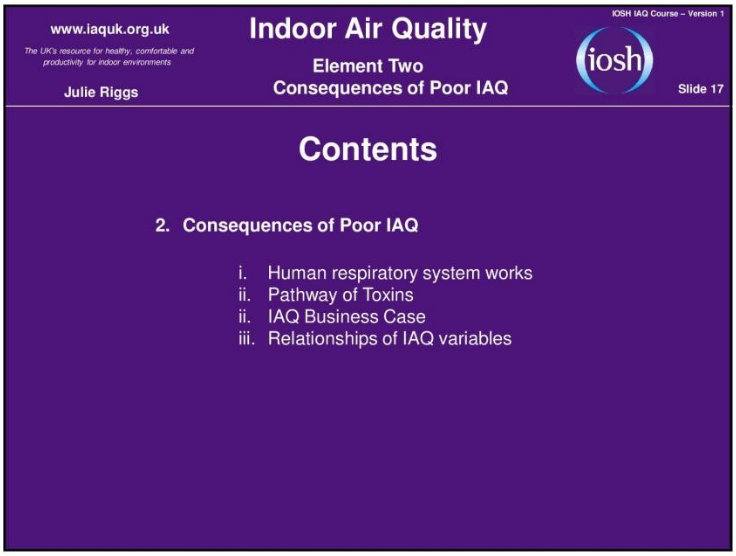
2. Consequences of Poor IAQ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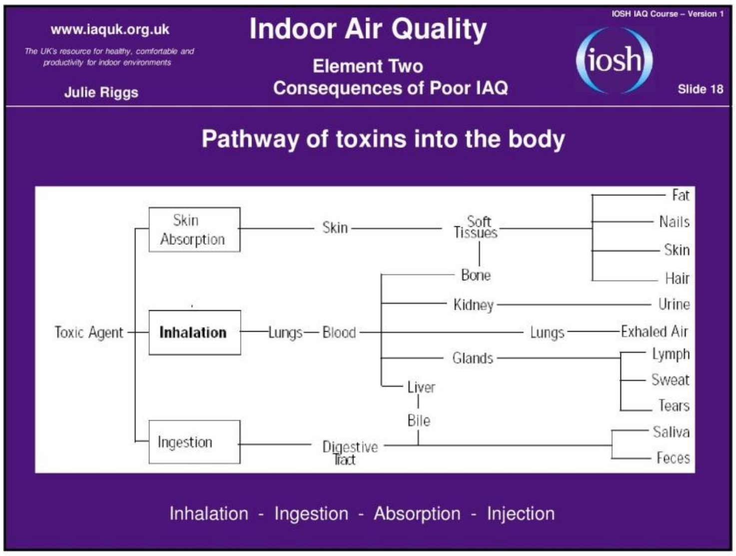
Contents
2. Consequences of Poor IAQ
i. Human respiratory system works
ii. Pathway of Toxins
ii. IAQ Business Case
iii. Relationships of IAQ variables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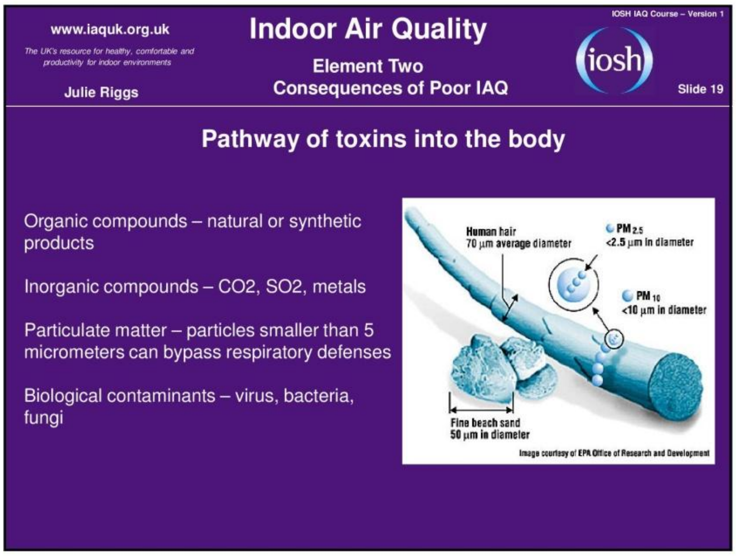
Slide 18
Pathway of toxins into the body
Toxic Agent
Skin Absorption
Inhalation
Ingestion
Skin
Lungs
Blood
Digestive Tract
Soft Tissues
Bone
Kidney
Glands
Liver
Bile
Lungs
Fat
Nails
Skin
Hair
Urine
Exhaled Air
Lymph
Sweat
Tears
Saliva
Feces
Inhalation - Ingestion - Absorption - Injection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Slide 19
Pathway of toxins into the body
Organic compounds – natural or synthetic products
Inorganic compounds – CO2, SO2, metals
Particulate matter – particles smaller than 5 micrometers can bypass respiratory defenses
Biological contaminants – virus, bacteria, fungi
Human hair
70 µm average diameter
PM 2.5
<2.5 µm in diameter
PM 10
<10 µm in diameter
Fine beach sand
50 µm in diameter
Image courtesy of EPA Office of Research and Development

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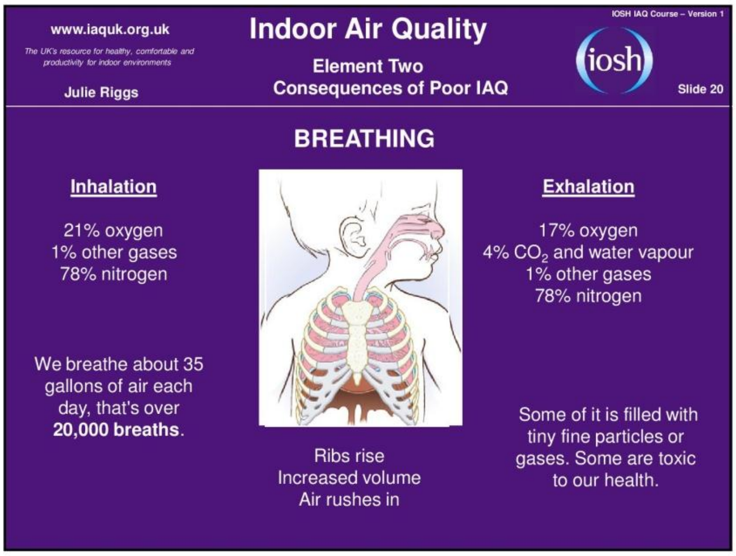
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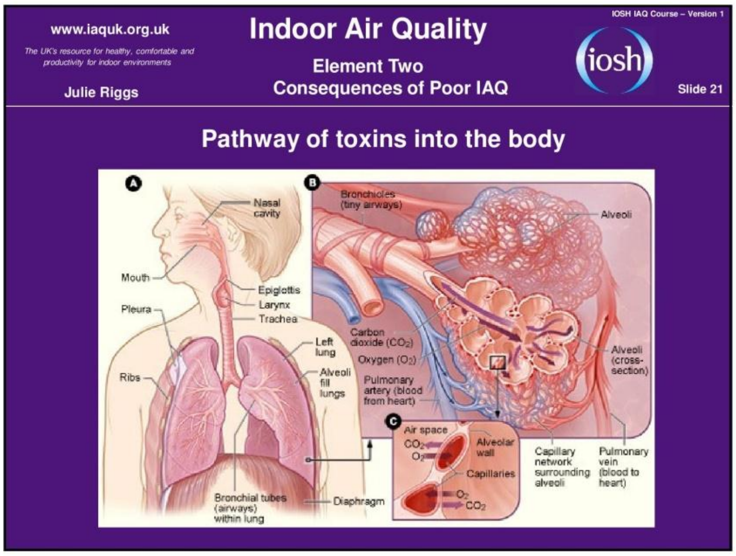
Slide 20
BREATHING
Inhalation
21% oxygen
1% other gases
78% nitrogen
We breathe about 35 gallons of air each day, that's over **20,000 breaths**.
Ribs rise
Increased volume
Air rushes in
Exhalation
17% oxygen
4% CO_2 and water vapour
1% other gases
78% nitrogen
Some of it is filled with tiny fine particles or gases. Some are toxic to our health.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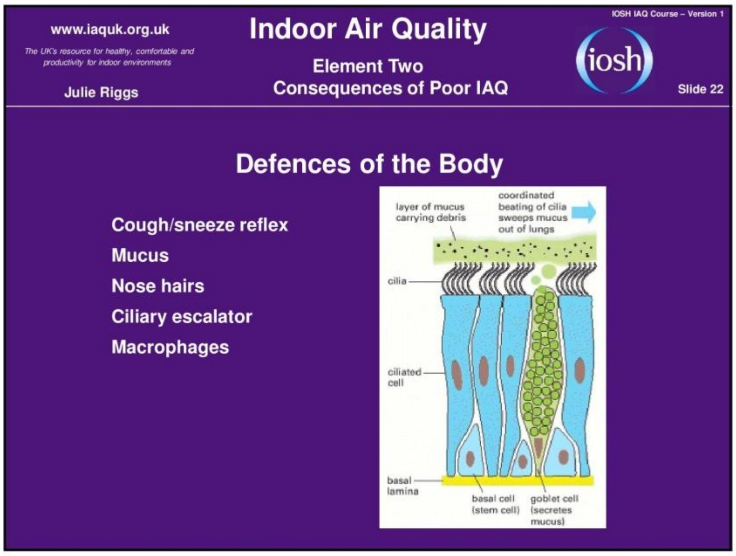
Pathway of toxins into the body
A
B
C
Nasal cavity
Mouth
Epiglottis
Larynx
Trachea
Pleura
Left lung
Ribs
Alveoli fill lungs
Bronchial tubes (airways) within lung
Diaphragm
Bronchioles (tiny airways)
Alveoli
Carbon dioxide (CO_2)
Oxygen (O_2)
Pulmonary artery (blood from heart)
Alveoli (cross-section)
Air space
Alveolar wall
Capillaries
Capillary network surrounding alveoli
Pulmonary vein (blood to heart)

11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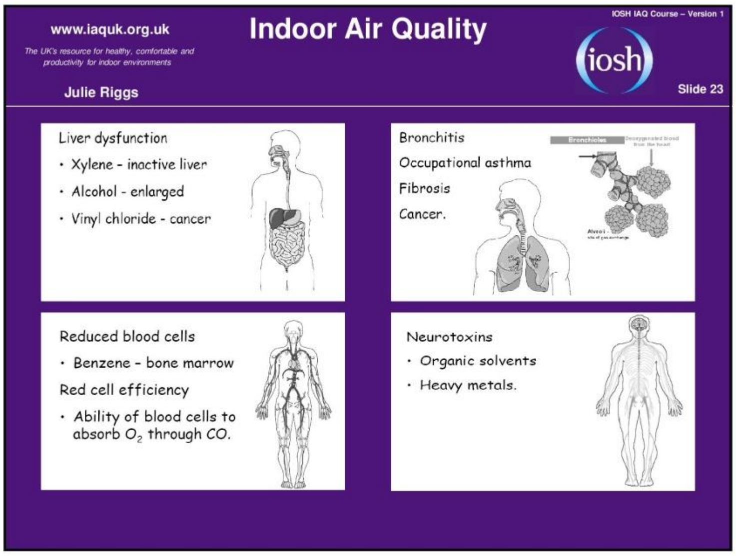
Defences of the Body
Cough/sneeze reflex
Mucus
Nose hairs
Ciliary escalator
Macrophages
layer of mucus carrying debris
coordinated beating of cilia sweeps mucus out of lungs
cilia
ciliated cell
basal lamina
basal cell (stem cell)
goblet cell (secretes mucus)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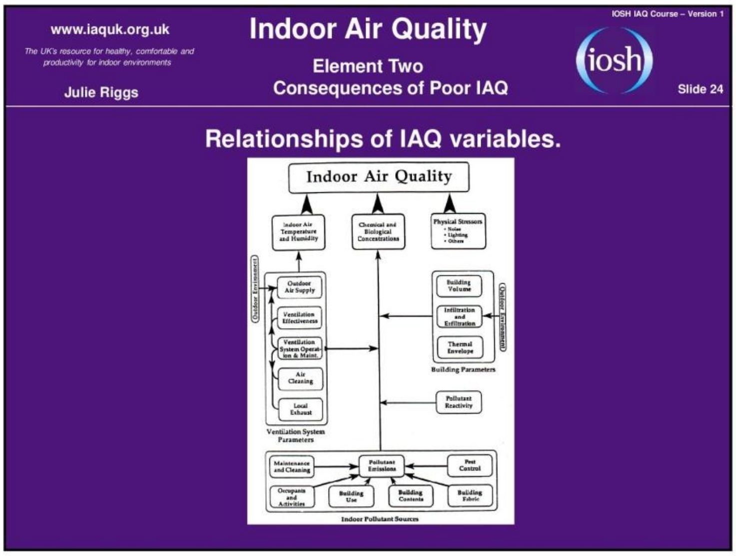
Liver dysfunction
• Xylene - inactive liver
• Alcohol - enlarged
• Vinyl chloride - cancer
Bronchitis
Occupational asthma
Fibrosis
Cancer.
Reduced blood cells
• Benzene – bone marrow
Red cell efficiency
• Ability of blood cells to absorb O_2 through CO.
Neurotoxins
• Organic solvents
• Heavy metals.

12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Relationships of IAQ variables.
Indoor Air Quality
Indoor Air Temperature and Humidity
Chemical and Biological Concentrations
Physical Stressors
• Noise
• Lighting
• Others
Outdoor Environment
Outdoor Air Supply
Ventilation Effectiveness
Ventilation System Operation & Maint.
Air Cleaning
Local Exhaust
Ventilation System Parameters
Building Volume
Infiltration and Exfiltration
Thermal Envelope
Outdoor Environment
Building Parameters
Pollutant Reactivity
Maintenance and Cleaning
Pollutant Emissions
Pest Control
Occupants and Activities
Building Use
Building Contents
Building Fabric
Indoor Pollutant Sources


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3. Ventilations

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Contents
3. Ventilations
i. Understanding ventilation
ii. Mechanical versus natural ventilation
iii. Different types and components of ventilation systems


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Ventilation
The Health and Safety Executive recommend a minimum fresh-air flow of 8 litres per second per person.
Activity:
Discussion
Why do we ventilate a building?

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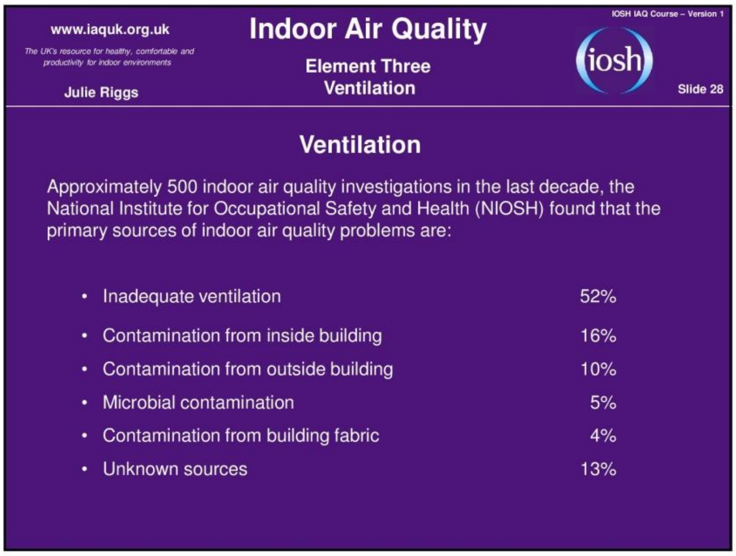
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Ventilation
Approximately 500 indoor air quality investigations in the last decade, the National Institute for Occupational Safety and Health (NIOSH) found that the primary sources of indoor air quality problems are:
• Inadequate ventilation 52%
• Contamination from inside building 16%
• Contamination from outside building 10%
• Microbial contamination 5%
• Contamination from building fabric 4%
• Unknown sources 13%


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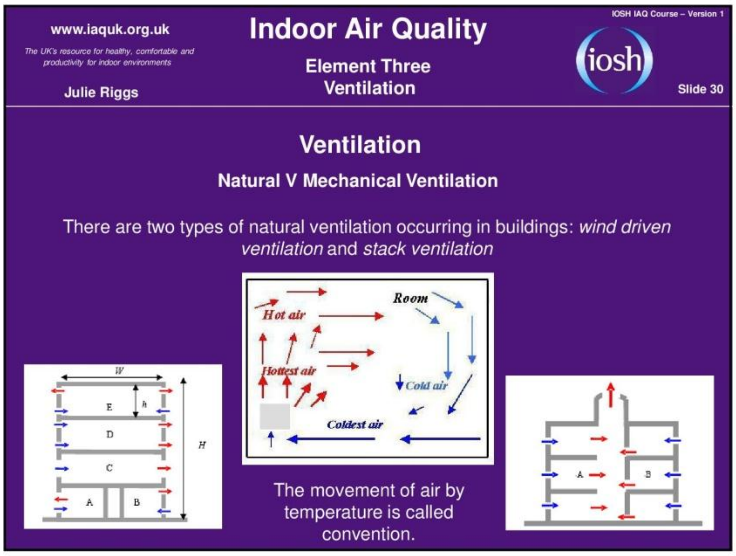
Ventilation
Natural V Mechanical Ventilation
Natural ventilation occurs when the air in a space is changed with outdoor air without the use of mechanical systems, such as a fan.
Mechanical or forced ventilation: through an air handling unit or direct injection to a space by a fan.
Mixed Mode Ventilation or Hybrid ventilation: utilises both mechanical and natural ventilation processes. The mechanical and natural components may be used in conjunction with each other or separately at different times of day.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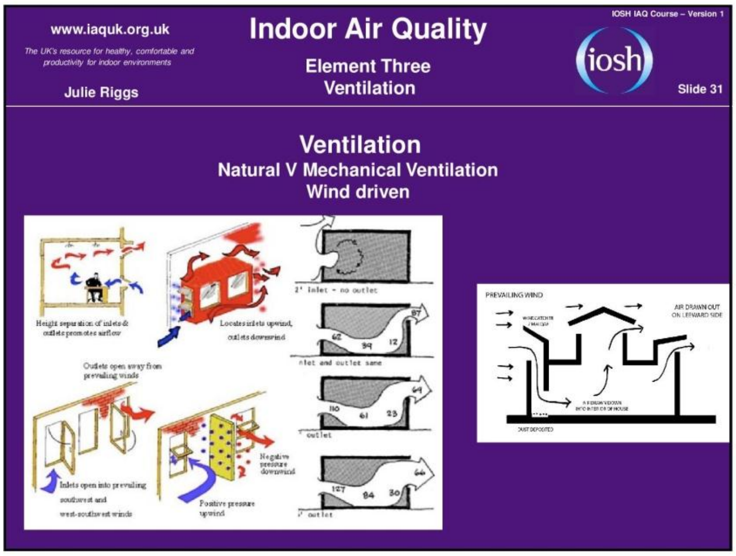
Ventilation
Natural V Mechanical Ventilation
There are two types of natural ventilation occurring in buildings: *wind driven ventilation* and *stack ventilation*
Room
Hot air
Hottest air
Cold air
Coldest air
The movement of air by temperature is called convention.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Ventilation
Natural V Mechanical Ventilation
Wind driven
Height separation of inlets & outlets promotes airflow
Locate inlets upwind, outlets downwind
Outlets open away from prevailing winds
Inlets open into prevailing southwest and west-southwest winds
Positive pressure upwind
Negative pressure downwind
PREVAILING WIND
AIR DRAWN OUT ON LEEWARD SIDE

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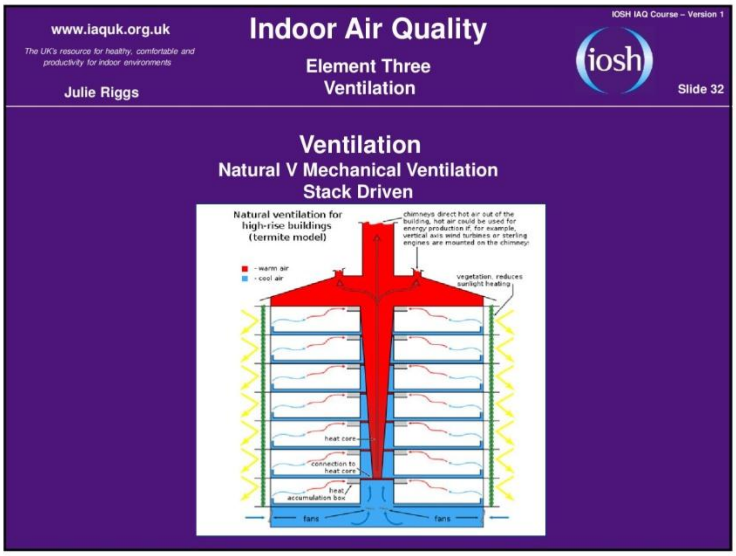
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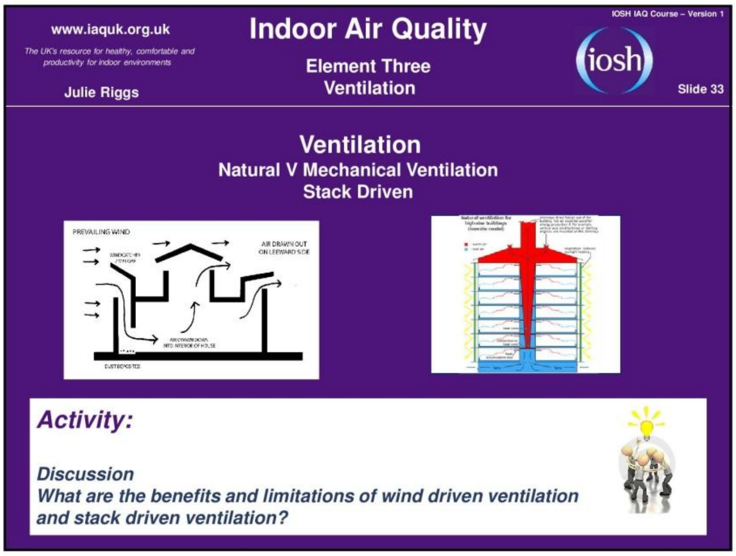
Ventilation
Natural V Mechanical Ventilation
Stack Driven
Natural ventilation for high-rise buildings (termite model)
chimneys direct hot air out of the building, hot air could be used for energy production if, for example, vertical axis wind turbines or sterling engines are mounted on the chimney
- warm air
- cool air
vegetation, reduces sunlight heating
heat core
connection to heat core
heat accumulation box
fans
fans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Ventilation
Natural V Mechanical Ventilation
Stack Driven
PREVAILING WIND
AIR DRAWN OUT ON LEEWARD SIDE
Activity:
Discussion
What are the benefits and limitations of wind driven ventilation and stack driven ventilation?

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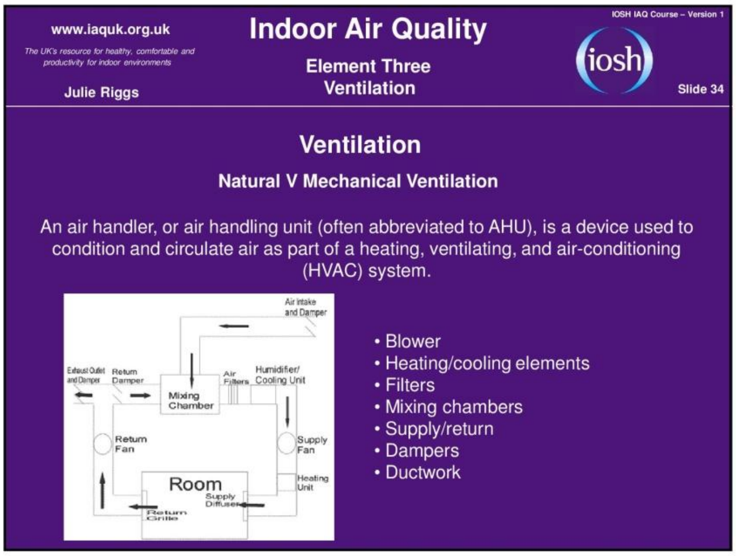
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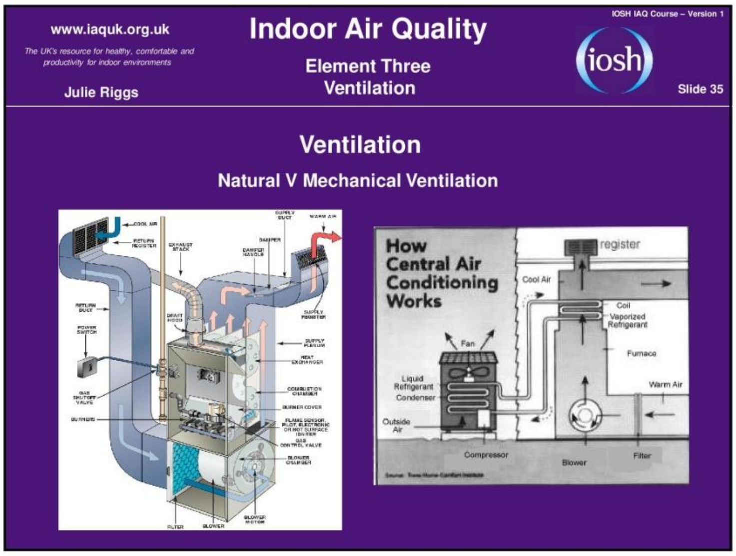
Ventilation
Natural V Mechanical Ventilation
An air handler, or air handling unit (often abbreviated to AHU), is a device used to condition and circulate air as part of a heating, ventilating, and air-conditioning (HVAC) system.
Air Intake and Damper
Exhaust Outlet and Damper
Return Damper
Mixing Chamber
Air Filters
Humidifier/ Cooling Unit
Return Fan
Supply Fan
Room
Heating Unit
Supply Diffuser
Return Grille
• Blower
• Heating/cooling elements
• Filters
• Mixing chambers
• Supply/return
• Dampers
• Ductwork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Ventilation
Natural V Mechanical Ventilation
How Central Air Conditioning Works
register
Cool Air
Coil
Vaporized Refrigerant
Furnace
Warm Air
Fan
Liquid Refrigerant
Condenser
Outside Air
Compressor
Blower
Filter

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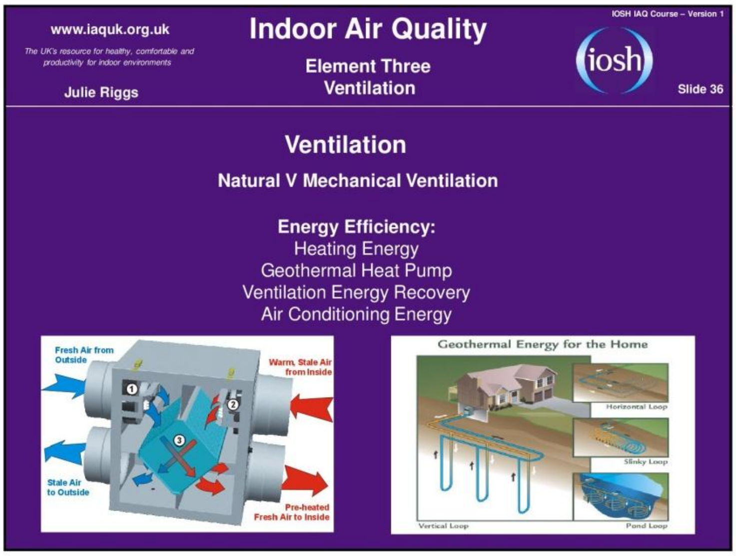
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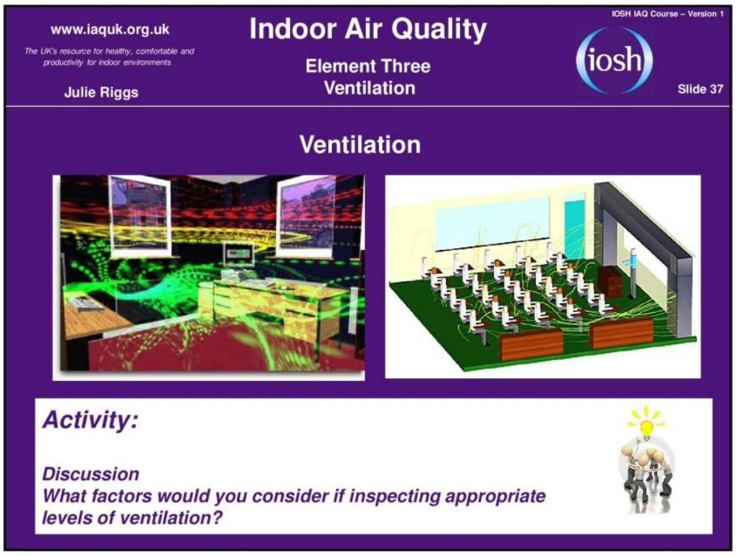
Ventilation
Natural V Mechanical Ventilation
Energy Efficiency:
Heating Energy
Geothermal Heat Pump
Ventilation Energy Recovery
Air Conditioning Energy
Fresh Air from Outside
Warm, Stale Air from Inside
Stale Air to Outside
Pre-heated Fresh Air to Inside
Geothermal Energy for the Home
Horizontal Loop
Slinky Loop
Vertical Loop
Pond Loop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Ventilation
Activity:
Discussion
What factors would you consider if inspecting appropriate levels of ventilation?

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Ventilation

Level 1 Walk-through

- Odours
- Dirty or unsanitary conditions
- Visible mould growth or mouldy odours
- Signs of leaks or moisture damage, stains or discoloration
- Hazardous substances
- Dirty mechanical room
- Rubbish or stored chemicals
- Poor maintenance or housekeeping
- Individual fans or heaters
- Covered diffusers
- Paper streamers on diffusers
- Overcrowding
- Blocked HVAC inlets or outlets
- Location and setting of thermostats
- Others?

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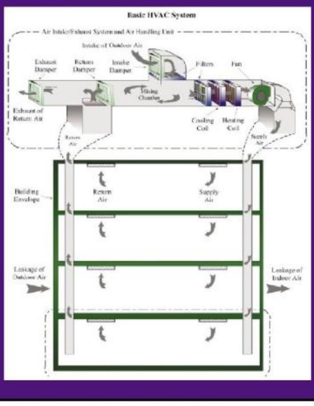
Ventilation

HVAC Inspection Level 2

- Outdoor air intake
- Outdoor/return/exhaust air
- Filters
- Heating and cooling coils
- Supply air fan
- Humidifier
- Ductwork



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Fundamental Components of IAQ

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Contents

4. Fundamental Components of IAQ

i. Understanding temperature
ii. Understanding humidity
iii. Understanding carbon dioxide

(Each section to explore composition about the component, such as source, health risks, comfort factors and influence on population)

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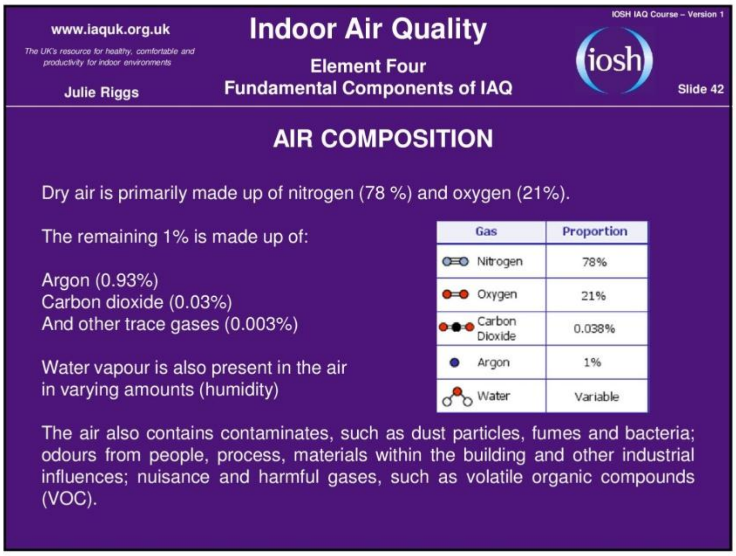
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AIR COMPOSITION
Dry air is primarily made up of nitrogen (78 %) and oxygen (21%).
The remaining 1% is made up of:
Argon (0.93%)
Carbon dioxide (0.03%)
And other trace gases (0.003%)
Water vapour is also present in the air in varying amounts (humidity)
Gas
Proportion
Nitrogen
78%
Oxygen
21%
Carbon Dioxide
0.038%
Argon
1%
Water
Variable
The air also contains contaminates, such as dust particles, fumes and bacteria; odours from people, process, materials within the building and other industrial influences; nuisance and harmful gases, such as volatile organic compounds (VOC).


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Temperature
According to the British Standards BS EN ISO 7730 the term thermal comfort is a 'state of mind that expresses satisfaction with the surrounding environment'.
Therefore thermal comfort is a subjective matter.
Activity:
Mindmap
What makes thermal comfort subjective?
(individuals/work space/environment)
The Health & Safety Executive recommend that employers should adopt a 'reasonable comfort' standard; quoting 80% of the workforce should be 'thermally comfortable'.

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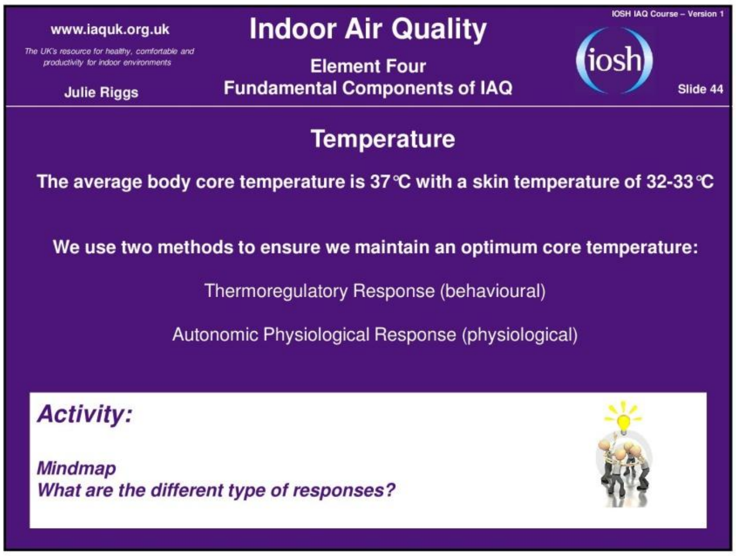
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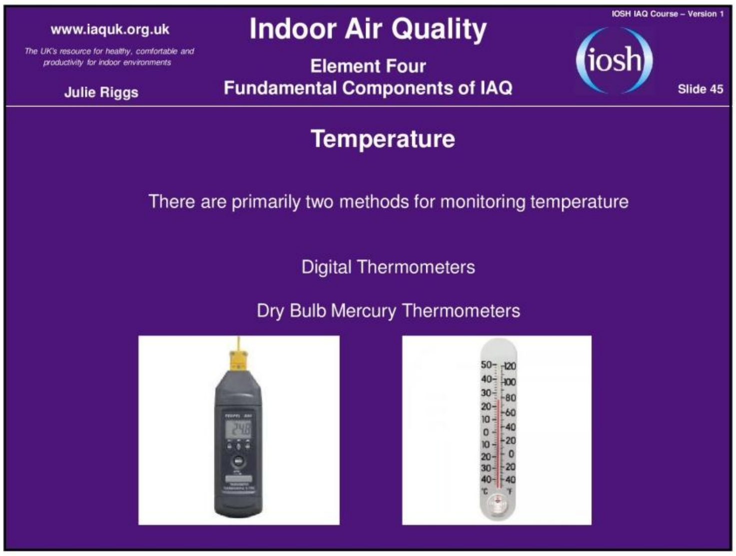
Temperature
The average body core temperature is 37°C with a skin temperature of 32-33°C
We use two methods to ensure we maintain an optimum core temperature:
Thermoregulatory Response (behavioural)
Autonomic Physiological Response (physiological)
Activity:
Mindmap
What are the different type of responses?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Temperature
There are primarily two methods for monitoring temperature
Digital Thermometers
Dry Bulb Mercury Thermometers

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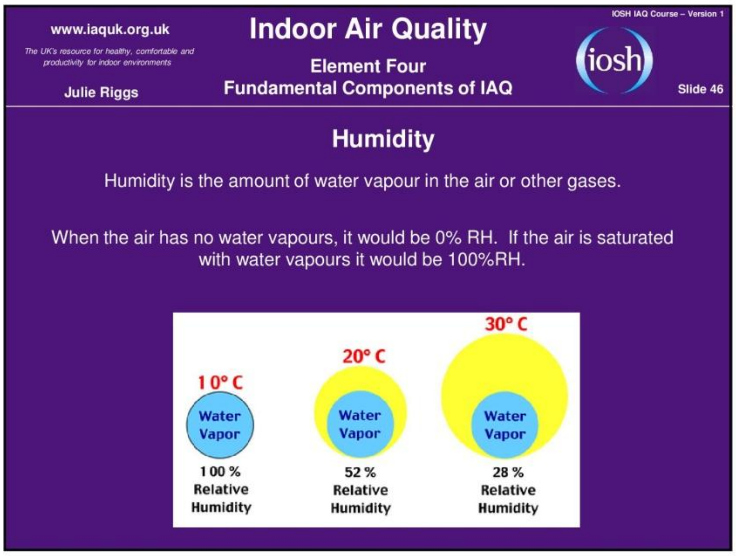
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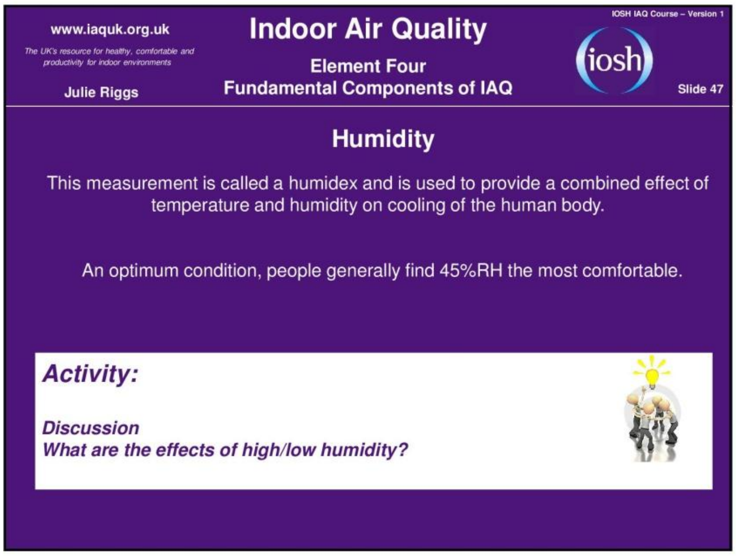
Humidity
Humidity is the amount of water vapour in the air or other gases.
When the air has no water vapours, it would be 0% RH. If the air is saturated with water vapours it would be 100%RH.
30° C
20° C
10° C
Water Vapor
Water Vapor
Water Vapor
100 % Relative Humidity
52 % Relative Humidity
28 % Relative Humidity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Humidity
This measurement is called a humidex and is used to provide a combined effect of temperature and humidity on cooling of the human body.
An optimum condition, people generally find 45%RH the most comfortable.
Activity:
Discussion
What are the effects of high/low humidity?

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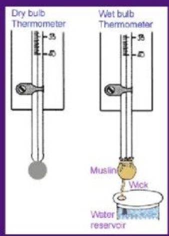
Humidity

Measuring

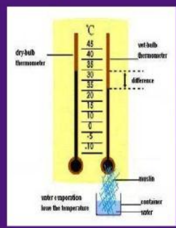
There are various methods to measuring and regulating humidity.

Hygrometers are instruments used for measuring humidity



Wet Bulb Thermometer (WBT)

Wet Bulb Globe Thermometer (WBGT)



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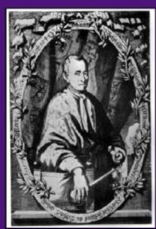
Carbon Dioxide (CO_2)

Jan Baptist van Helmont 'Wild Spirit'

Carbon dioxide derives primarily from combustion of organic matters

Used within industry



Typical indoor concentrations can range from 380 ppm – 2500 ppm

EH40/2005 - 5000 ppm long term exposure (8 hour TWA)

1,000ppm have be shown to affect the body physically and psychologically.

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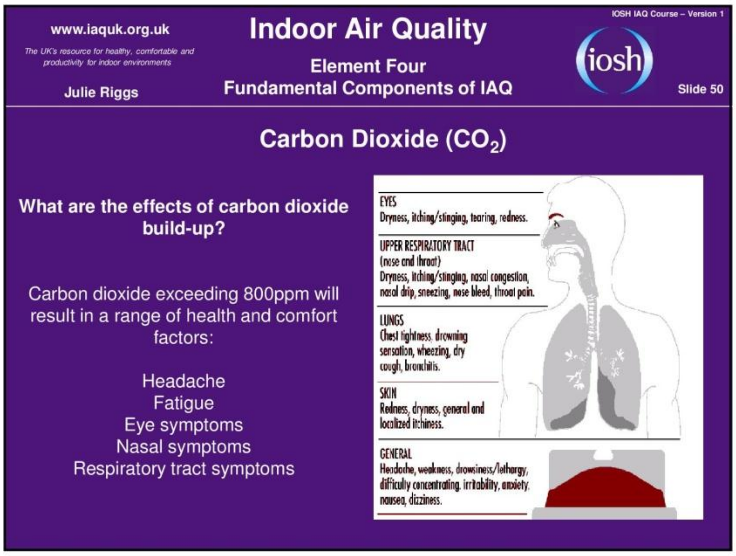
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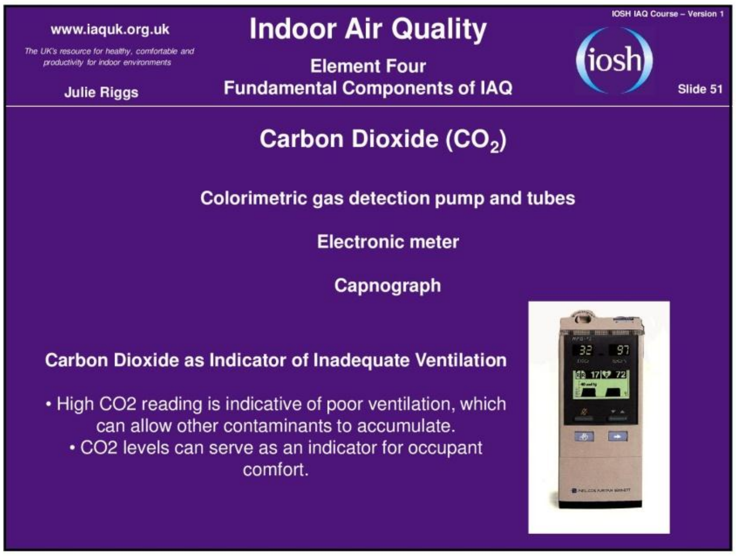
Carbon Dioxide (CO_2)
What are the effects of carbon dioxide build-up?
Carbon dioxide exceeding 800ppm will result in a range of health and comfort factors:
Headache
Fatigue
Eye symptoms
Nasal symptoms
Respiratory tract symptoms
EYES
Dryness, itching/stinging, tearing, redness.
UPPER RESPIRATORY TRACT
(nose and throat)
Dryness, itching/stinging, nasal congestion, nasal drip, sneezing, nose bleed, throat pain.
LUNGS
Chest tightness, drowning sensation, wheezing, dry cough, bronchitis.
SKIN
Redness, dryness, general and localized itchiness.
GENERAL
Headache, weakness, drowsiness/lethargy, difficulty concentrating, irritability, anxiety, nausea, dizziness.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Carbon Dioxide (CO_2)
Colorimetric gas detection pump and tubes
Electronic meter
Capnograph
Carbon Dioxide as Indicator of Inadequate Ventilation
• High CO2 reading is indicative of poor ventilation, which can allow other contaminants to accumulate.
• CO2 levels can serve as an indicator for occupant comfort.

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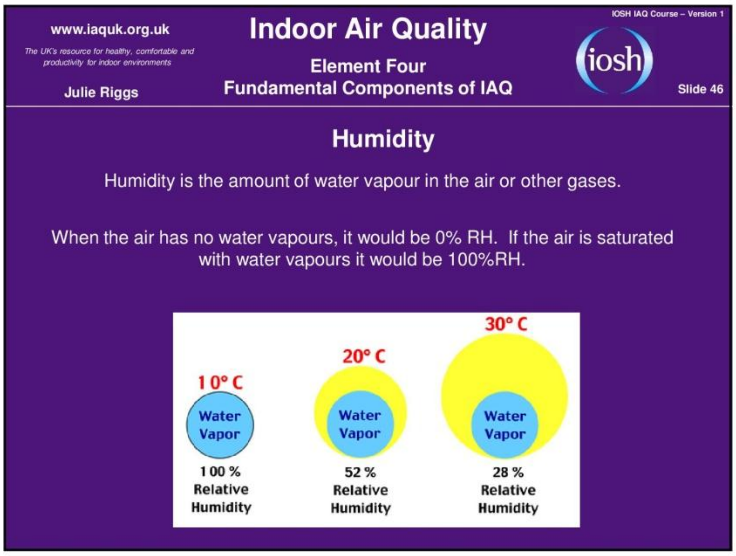
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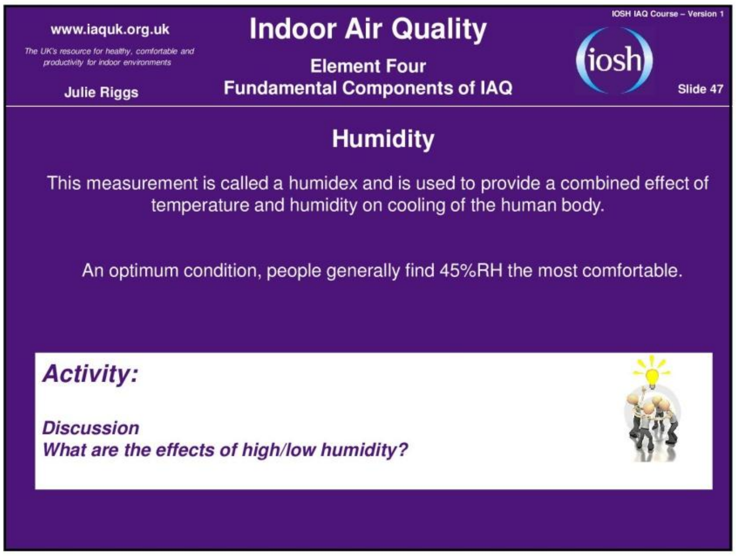
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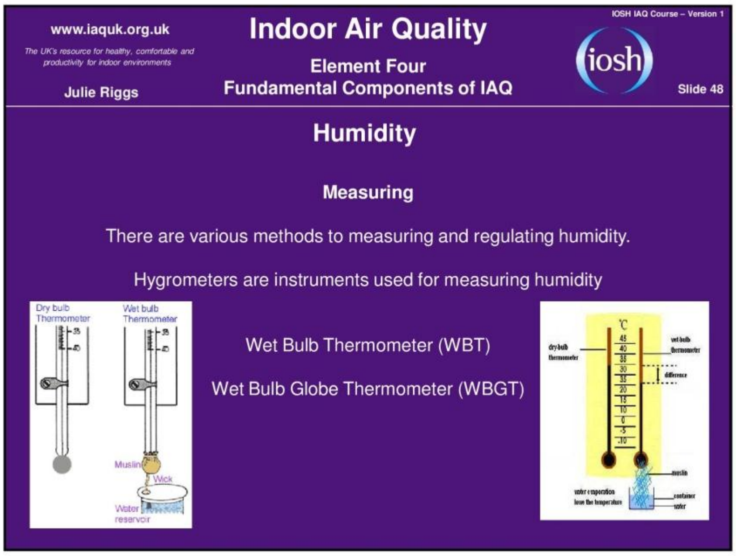
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Humidity
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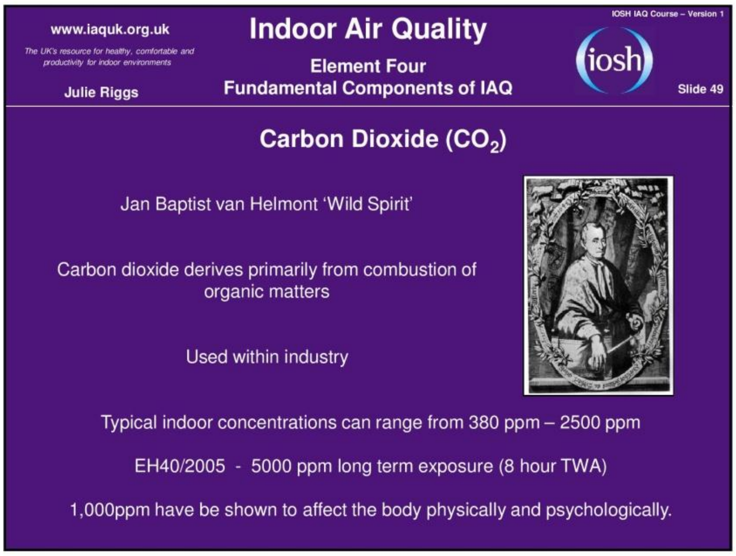
Wet bulb Thermometer
Muslin
Wick
Water reservoir
Wet Bulb Thermometer (WBT)
Wet Bulb Globe Thermometer (WBGT)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Jan Baptist van Helmont 'Wild Spirit'
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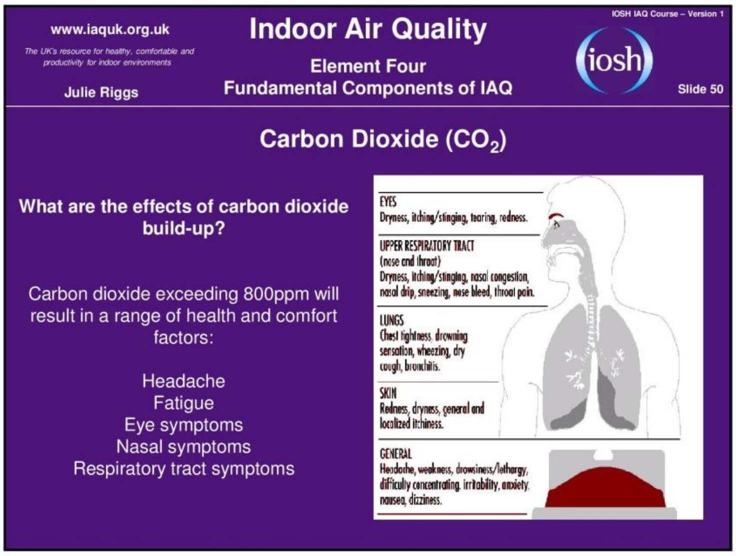

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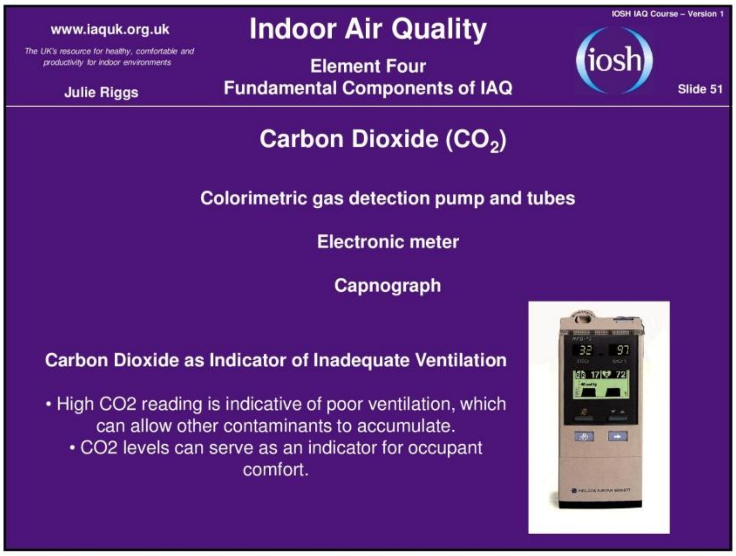

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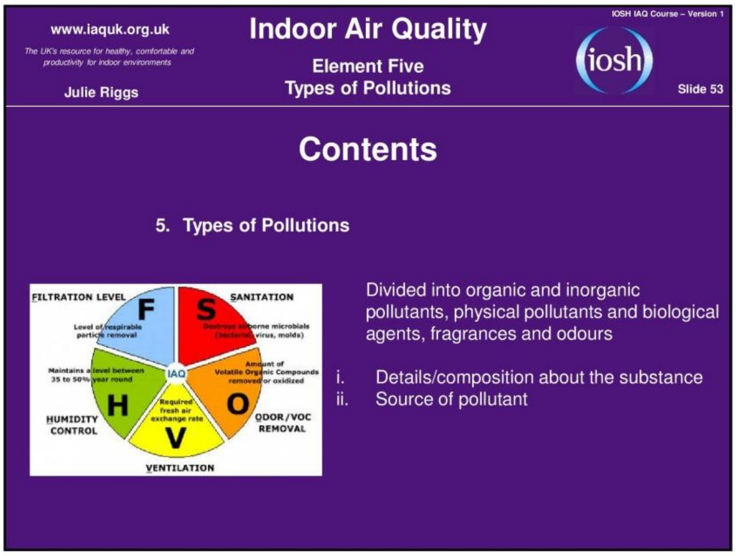
5. Types of Pollutions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Contents
5. Types of Pollutions
FILTRATION LEVEL
SANITATION
IAQ
HUMIDITY CONTROL
ODOR / VOC REMOVAL
VENTILATION
F
S
H
O
V
Divided into organic and inorganic pollutants, physical pollutants and biological agents, fragrances and odours
i. Details/composition about the substance
ii. Source of pollutant

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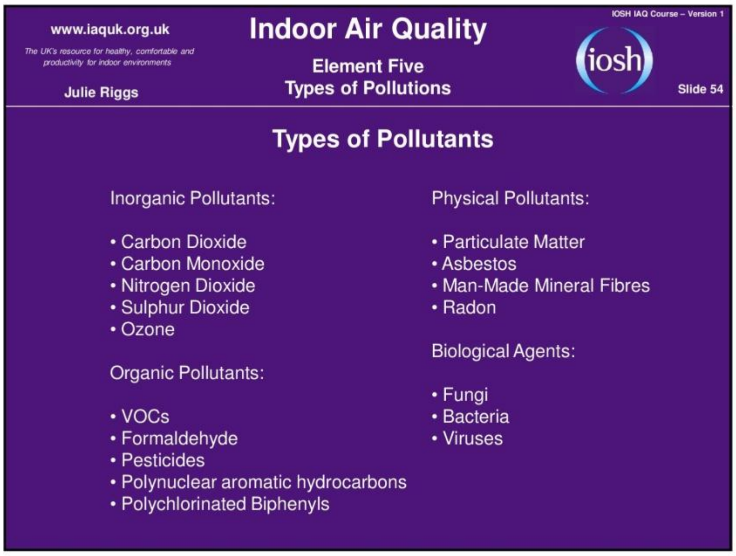
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Types of Pollutants
Inorganic Pollutants:
• Carbon Dioxide
• Carbon Monoxide
• Nitrogen Dioxide
• Sulphur Dioxide
• Ozone
Organic Pollutants:
• VOCs
• Formaldehyde
• Pesticides
• Polynuclear aromatic hydrocarbons
• Polychlorinated Biphenyls
Physical Pollutants:
• Particulate Matter
• Asbestos
• Man-Made Mineral Fibres
• Radon
Biological Agents:
• Fungi
• Bacteria
• Viruses


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Types of Pollutants
Inorganic Pollutants:
• Carbon Dioxide
• Carbon Monoxide
• Nitrogen Dioxide
• Sulphur Dioxide
• Ozone
Inorganic is said of any substance in which two or more chemical elements other than carbon are combined.
Every chemical is either inorganic or organic.
• Sources
• Health Effects

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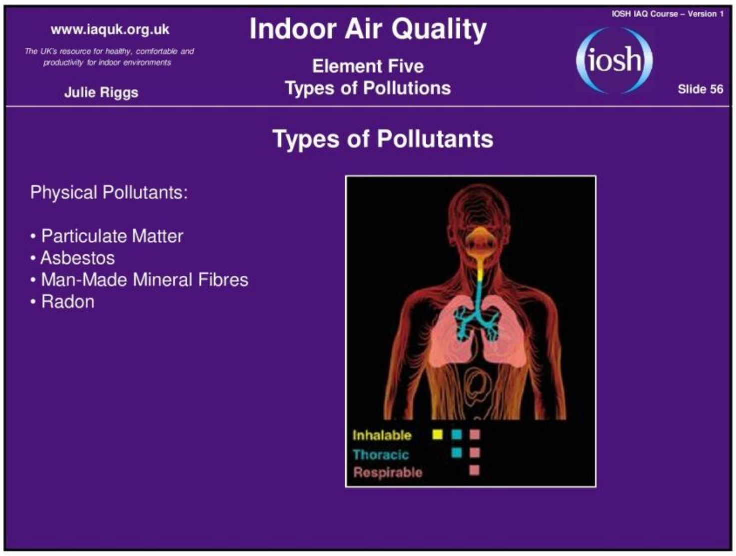
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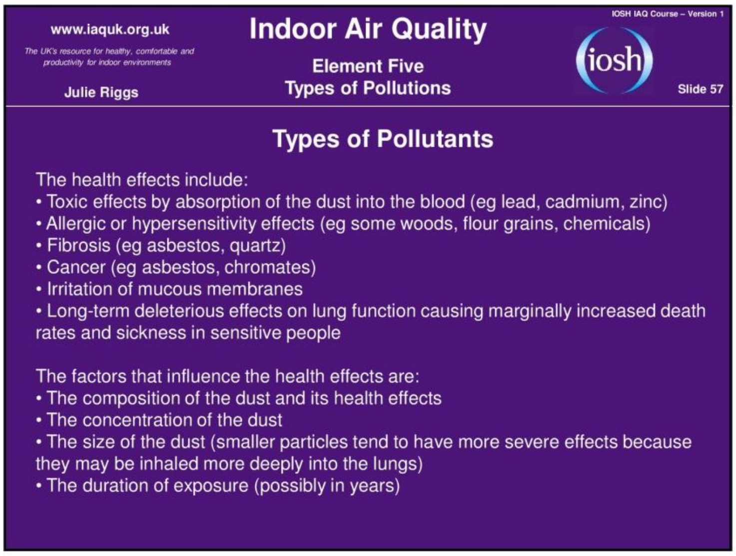
Types of Pollutants
Physical Pollutants:
• Particulate Matter
• Asbestos
• Man-Made Mineral Fibres
• Radon
Inhalable
Thoracic
Respirable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Types of Pollutants
The health effects include:
• Toxic effects by absorption of the dust into the blood (eg lead, cadmium, zinc)
• Allergic or hypersensitivity effects (eg some woods, flour grains, chemicals)
• Fibrosis (eg asbestos, quartz)
• Cancer (eg asbestos, chromates)
• Irritation of mucous membranes
• Long-term deleterious effects on lung function causing marginally increased death rates and sickness in sensitive people
The factors that influence the health effects are:
• The composition of the dust and its health effects
• The concentration of the dust
• The size of the dust (smaller particles tend to have more severe effects because they may be inhaled more deeply into the lungs)
• The duration of exposure (possibly in years)

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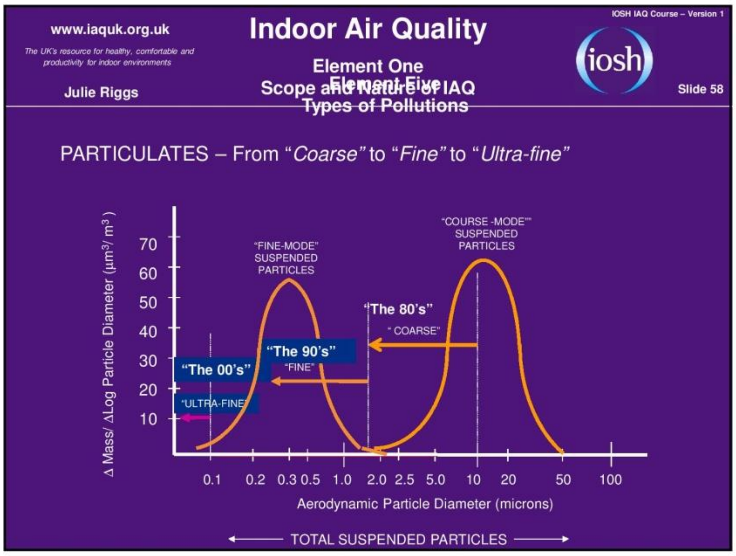

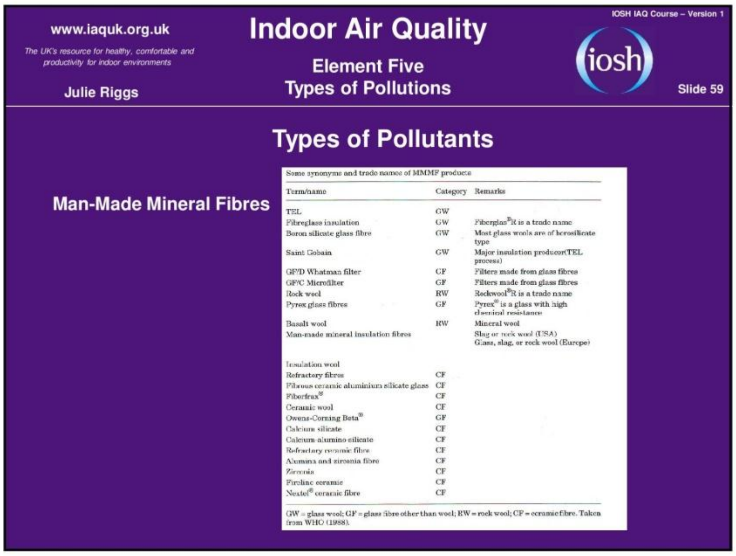

Some synonyms and trade names of MMMF products

Term/name	Category	Remarks
TEL	GW	
Fibreglass insulation	GW	Fiberglas®R is a trade name
Boron silicate glass fibre	GW	Most glass wools are of borosilicate type
Saint Gobain	GW	Major insulation producer(TEL process)
GF/D Whatman filter	CF	Filters made from glass fibres
GF/C Microfilter	GF	Filters made from glass fibres
Rock wool	RW	Rockwool®R is a trade name
Pyrex glass fibres	GF	Pyrex® is a glass with high chemical resistance
Basalt wool	RW	Mineral wool
Man-made mineral insulation fibres		Slag or rock wool (USA) Glass, slag, or rock wool (Europe)
Insulation wool		
Refractory fibres	CF	
Fibrous ceramic aluminium silicate glass	CF	
Fiberfrax®	CF	
Ceramic wool	CF	
Owens-Corning Beta®	GF	
Calcium silicate	CF	
Calcium-alumino-silicate	CF	
Refractory ceramic fibre	CF	
Alumina and zirconia fibre	CF	
Zirconia	CF	
Fireline ceramic	CF	
Nextel® ceramic fibre	CF	

GW = glass wool; GF = glass fibre other than wool; RW = rock wool; CF = ceramic fibre. Taken from WHO (1988).

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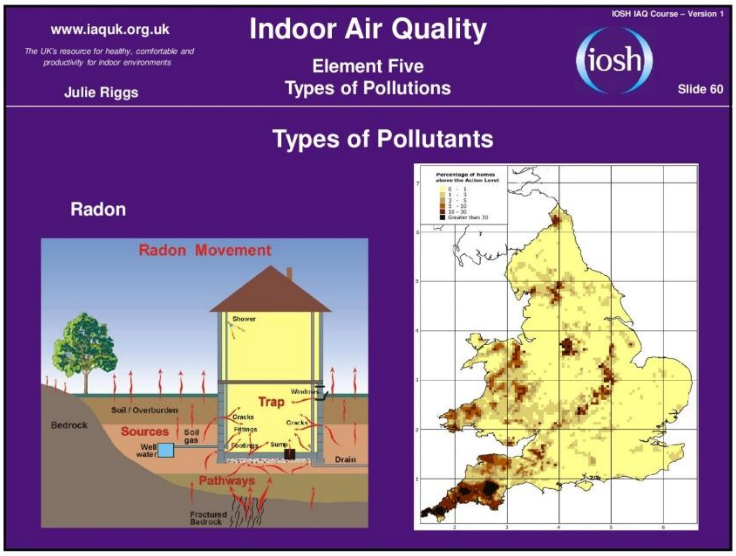

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Types of Pollutants
Radon
Radon Movement
Shower
Soil / Overburden
Bedrock
Sources
Soil gas
Well water
Trap
Cracks
Fittings
Footings
Sump
Window
Drain
Pathways
Fractured Bedrock

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Types of Pollutants
Biological Agents:
• Fungi
• Bacteria
• Viruses

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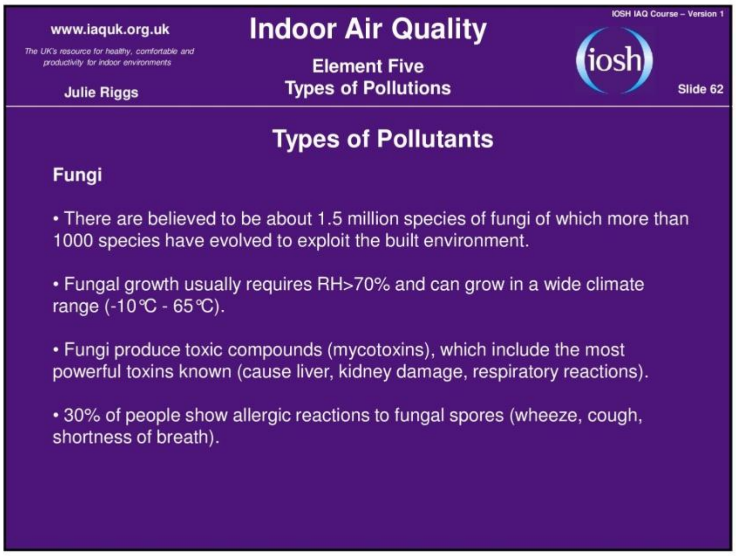
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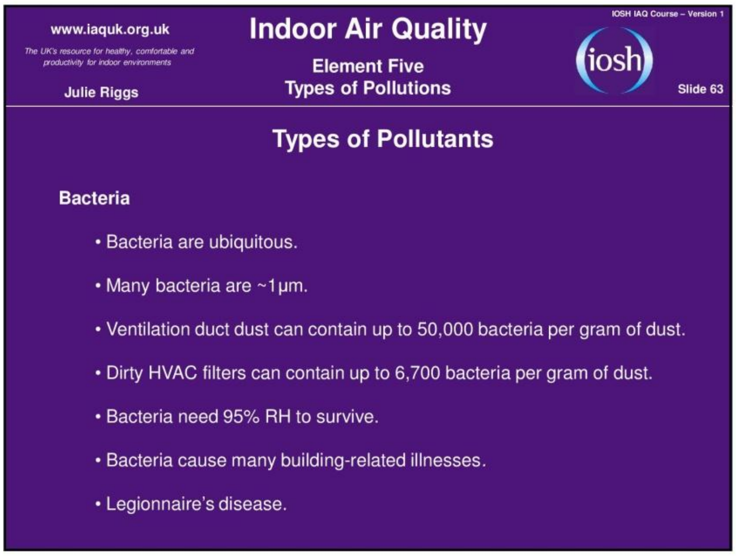
Types of Pollutants
Fungi
• There are believed to be about 1.5 million species of fungi of which more than 1000 species have evolved to exploit the built environment.
• Fungal growth usually requires RH>70% and can grow in a wide climate range (-10℃ - 65℃).
• Fungi produce toxic compounds (mycotoxins), which include the most powerful toxins known (cause liver, kidney damage, respiratory reactions).
• 30% of people show allergic reactions to fungal spores (wheeze, cough, shortness of breath).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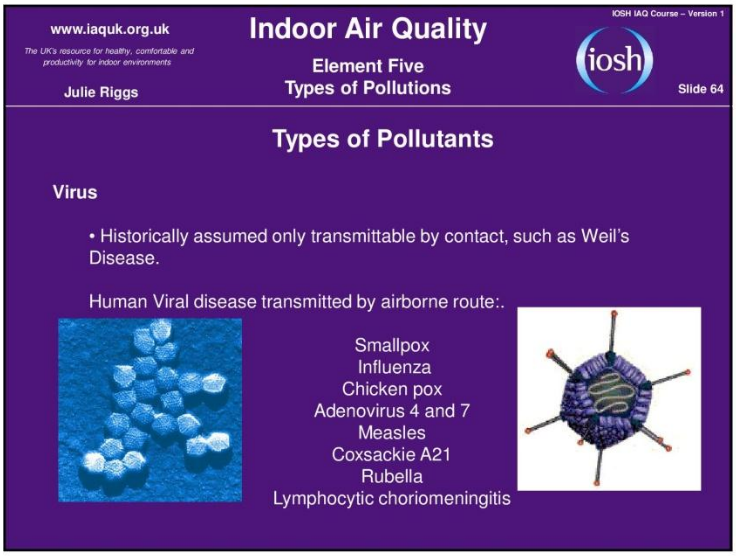
Types of Pollutants
Bacteria
• Bacteria are ubiquitous.
• Many bacteria are ~1µm.
• Ventilation duct dust can contain up to 50,000 bacteria per gram of dust.
• Dirty HVAC filters can contain up to 6,700 bacteria per gram of dust.
• Bacteria need 95% RH to survive.
• Bacteria cause many building-related illnesses.
• Legionnaire's disease.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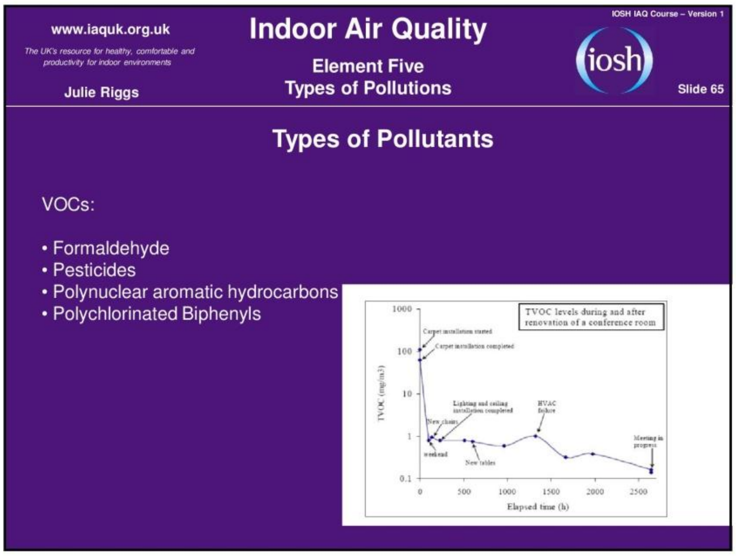
Types of Pollutants
Virus
• Historically assumed only transmittable by contact, such as Weil's Disease.
Human Viral disease transmitted by airborne route:.
Smallpox
Influenza
Chicken pox
Adenovirus 4 and 7
Measles
Coxsackie A21
Rubella
Lymphocytic choriomeningitis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Types of Pollutants
VOCs:
• Formaldehyde
• Pesticides
• Polynuclear aromatic hydrocarbons
• Polychlorinated Biphenyls
TVOC levels during and after renovation of a conference room
Carpet installation started
Carpet installation completed
New chairs
Lighting and ceiling installation completed
weekend
New tables
HVAC failure
Meeting in progress
TVOC (mg/m3)
Elapsed time (h)
1000
100
10
1
0.1
0
500
1000
1500
2000
2500

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Volatile Organic Compounds (VOC)
Reduce products that contain the following emissions:
Benzene;
Ethylbenzene (plastics, polystyrene)
Xylenes (solvent in printing, rubber and leather industries)
Methylene chloride (solvent, paint stripper, degreaser, aerosol spray propelants)
Tetrachloroethylene (solvent in dry cleaning, degreaser, paint stripper)
Formaldehyde (Preservation, disinfectants, solvents, photography processing)
Toluene (paint thinners, solvents)
Ethylene glycol (anti-freeze, often used in cars)
1,3-butadiene (Nylon, tyres, synthetic rubber)
Nonanal (used in flavours and perfume)
Phenol (used in cosmetics, hair dye, herbicides)
Isopropoanol (Solvent, cleaner, usually for electronic products)
Acetone (Solvent, paint thinner, nail polish remover, dry agent).


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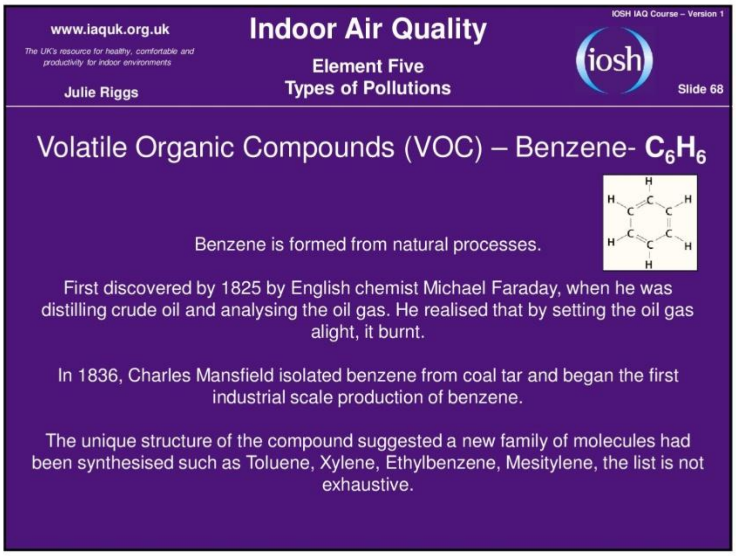
Volatile Organic Compounds (VOC)
Rolls Royce analysed a 1965 Silver Cloud.
Manufacturers are beginning to incorporate VOC reduction within their environment strategies.
Paints contribute towards less than 1% of all man-made VOCs in the UK, however the British Coating Industry have adopted a volunteer industry agreement to display VOC labels on all decorative coatings.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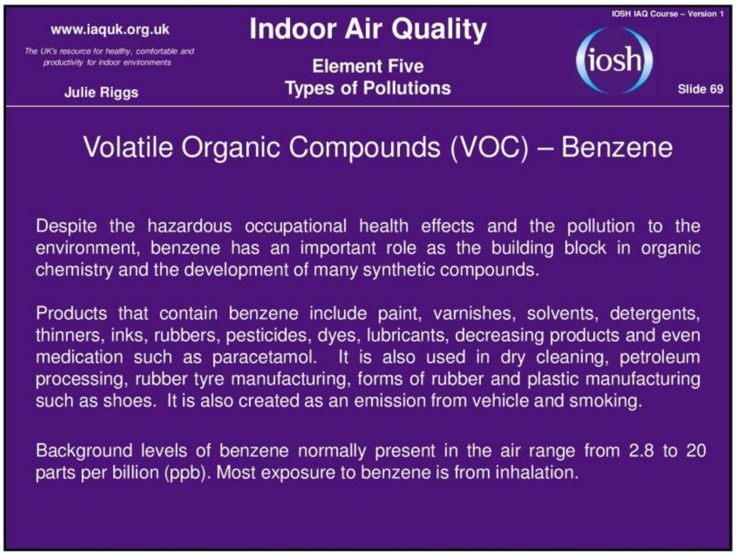
Volatile Organic Compounds (VOC) – Benzene- C_6H_6
Benzene is formed from natural processes.
First discovered by 1825 by English chemist Michael Faraday, when he was distilling crude oil and analysing the oil gas. He realised that by setting the oil gas alight, it burnt.
In 1836, Charles Mansfield isolated benzene from coal tar and began the first industrial scale production of benzene.
The unique structure of the compound suggested a new family of molecules had been synthesised such as Toluene, Xylene, Ethylbenzene, Mesitylene, the list is not exhaustive.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Volatile Organic Compounds (VOC) – Benzene
Despite the hazardous occupational health effects and the pollution to the environment, benzene has an important role as the building block in organic chemistry and the development of many synthetic compounds.
Products that contain benzene include paint, varnishes, solvents, detergents, thinners, inks, rubbers, pesticides, dyes, lubricants, decreasing products and even medication such as paracetamol. It is also used in dry cleaning, petroleum processing, rubber tyre manufacturing, forms of rubber and plastic manufacturing such as shoes. It is also created as an emission from vehicle and smoking.
Background levels of benzene normally present in the air range from 2.8 to 20 parts per billion (ppb). Most exposure to benzene is from inhalation.

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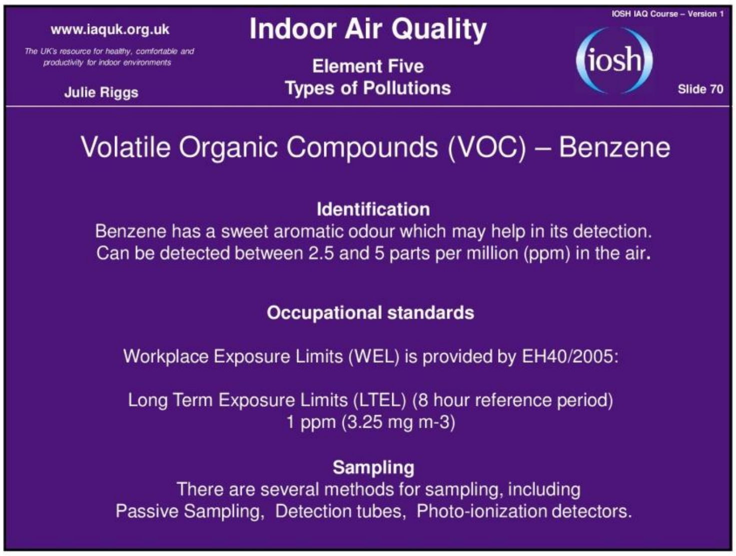
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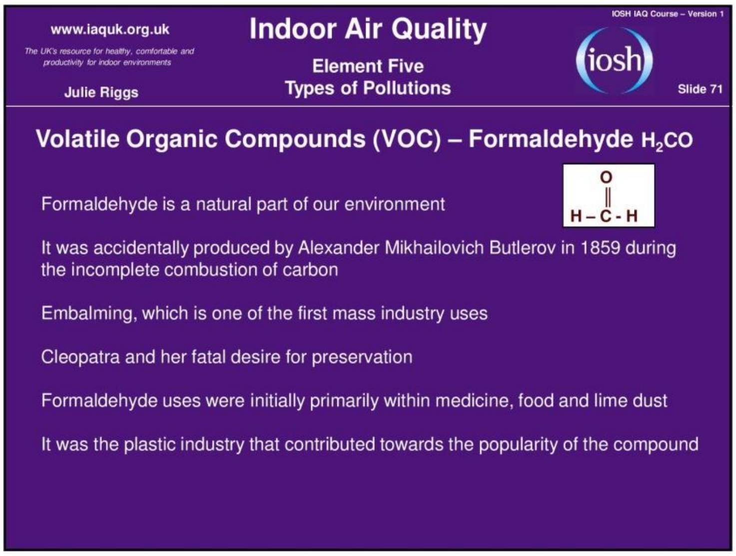
Volatile Organic Compounds (VOC) – Benzene
Identification
Benzene has a sweet aromatic odour which may help in its detection.
Can be detected between 2.5 and 5 parts per million (ppm) in the air.
Occupational standards
Workplace Exposure Limits (WEL) is provided by EH40/2005:
Long Term Exposure Limits (LTEL) (8 hour reference period)
1 ppm (3.25 mg m-3)
Sampling
There are several methods for sampling, including
Passive Sampling, Detection tubes, Photo-ionization detectors.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Volatile Organic Compounds (VOC) – Formaldehyde H_2CO
O
H – C - H
Formaldehyde is a natural part of our environment
It was accidentally produced by Alexander Mikhailovich Butlerov in 1859 during the incomplete combustion of carbon
Embalming, which is one of the first mass industry uses
Cleopatra and her fatal desire for preservation
Formaldehyde uses were initially primarily within medicine, food and lime dust
It was the plastic industry that contributed towards the popularity of the compound

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Volatile Organic Compounds (VOC) - Formaldehyde

- Plywood
- Carpets
- Sanitary paper products
- Tissues
- Insulation
- Resins
- Cast into moulded products
- Inks (used on currency)
- Paints
- Explosives
- Fabrics crease-resistant
- Shampoo

Car - front bumper to the rear bumper, formaldehyde-based materials are key to the manufacture of automobiles. They are used to produce components in the transmission, electrical system, engine block, door panels, axles, brake shoes and paint.

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Volatile Organic Compounds (VOC) - Formaldehyde

Short term health effects often initially displayed as irritation to the nose, throat and eyes. Individuals may also complain of headaches or feelings of nausea, even breathlessness has been associated.

Long term exposure can cause a decrease of the lung function capacity.

Because formaldehyde is a hardening agent, it can cause similar effects to the skin.

Formaldehyde is a sensitising agent to the skin and respiratory system.

Menstrual and thyroid irregularities, the impairing of cognitive functions including memory and concentration and contributing to sleep disturbances have been recognised as potential symptoms.

Existing health (asthma) and lifestyle habits such as smoking, which contains high concentrates of formaldehyde, will also influence exposure responses.

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Volatile Organic Compounds (VOC) - Formaldehyde

Occupational standards

Workplace Exposure Limits (WEL) is provided by EH40/2005:

Long Term Exposure Limits (LTEL) (8 hour reference period)
2 ppm (2.5 mg m-3)

Short Term Exposure Limits (STEL) (15 minute reference period)
2 ppm (2.5 mg m-3)

0.1 ppm is the Swedish indoor standard.

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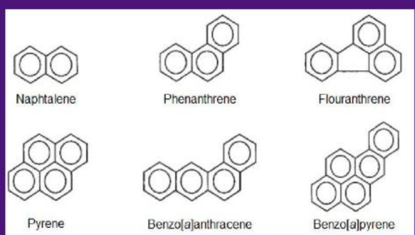
Polynuclear aromatic hydrocarbons

PAHs often are by-products of petroleum processing or combustion. Many of these compounds are highly carcinogenic at relatively low levels. Although they are relatively insoluble in water .



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Polychlorinated Biphenyls

The commercial production of PCBs started in 1929 but their use has been banned or severely restricted in many countries since the 1970s and 80s because of the possible risks to human health and the environment.
As PCBs are resistant to acids and bases as well as to heat, they have been used as an insulating material in electric equipment, such as transformers and capacitors, and also in heat transfer fluids and in lubricants. PCBs have also been used in wide range of products such as plasticizers, surface coatings, inks, adhesives, flame-retardants, paints, and carbonless duplicating paper.

Since 1929 around 2 million tonnes of PCBs have been produced, about 10% of which still remain in the environment today.

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1. *Copier/Printer Room*
   - Ozone
   - VOCs
   - Carbon Black
   - Other Particulates
2. *Storage/Cleaning Room*
   - Cleaning Products (VOCs)
   - Pesticides & Herbicides
   - Non-HEPA Vacuum
3. *Conference Room*
   - VOCs (Furniture/Markers)
   - Particulates (Chalk)
   - Improper Air Exchange
   - Carbon Dioxide Build-up
4. *Manufacturing Room*
   - Improper Ventilation Rates
   - Temperature Extremes
   - VOCs
   - Particulates
5. *Office Room*
   - VOCs (Furnishing)
   - Pesticides (Applies/Tracked)
   - Improper Ventilation
   - Computers (VOCs/Ozone/Particulates)
6. *Bathroom*
   - Air Fresheners (VOCs)
   - Cleaning Products (VOCs)
   - Sewage Gas
   - Water Leaks(Mold/Bacteria/Viruses)
7. *Break Room*
   - Cooking Odors/Oven Fumes
   - Tobacco Smoke
   - Water Leaks (Mold/Bacteria)
   - Allergens (Cockroach/Mouse/Rat)
8. *Cooling Tower*
   - Legionnaire's Disease
   - Pontiac Fever
   - Humidifier Fever
   - Improper Use of Biocides
   - Elevated Humidity
9. *Birds*
   - Odors & Allergens
   - Histoplasmosis
   - Cryptococcosis & Psitticosis
10. *Intake Vent*
    - Intake of Contaminated Air/Exhaust Entrainment
    - Improper or Lack of Filtration
    - Improper Sizing
11. *Exhaust Vent*
    - Entrainment Into Air Intake Vents
    - Excessive Exhaust (Causing the Structure to Have Negative Pressure)
    - Improper Sizing
12. *Trash Containers*
    - Odors
    - Bacteria
    - Fungi
    - Rodent/Insect Avian Allergens
    - Particulates
13. *Loading Dock*
    - Exhaust/Combustion Fumes
    - Carbon Monoxide
    - Chemical Storage/Spills
    - Outdoor Air Entry Portal (By passing Proper Filtration Radon Risk - Underground Areas)
14. *Cubicle Room*
    - Computers (Ozone/VOCs)
    - Electromagnetic Field/Particles Inadequate Ventilation Furniture (VOCs)
15. *Boiler Room*
    - Improper Combustion (Particulates/Gases)
    - Improper Ventilation
    - Asbestos Insulation
    - Fiberglass Insulation
    - Legionella from Improperly Heated Water Tank
16. *Plants*
    - Pollen
    - Fungi
    - Insects
    - Insecticides/Fungicides/ Herbicides
    - Standing Water
17. *Moisture Intrusion*
    - Leaks
    - Wicking of Moisture (Slab/Walls/Roof)
    - Mold, MVOCs & Mycotoxins
    - Bacteria & Endotoxins
18. *Carpeting/Flooring*
    - Potential Microbial & Chemical Reservoir
    - VOCs
    - Asbestos Floor Tiles
    - Improperly Sealed Concrete
19. *Ductwork/Ventilation*
    - Improper Exchange Rate
    - Fiberglass Insulation
    - Contaminated Ductwork (Dust/Pollen/Fungi/Bacteria)
    - Temperature Extremes
    - Improper Filtration
20. *People*
    - Perfume/Cologne
    - Body Odor
    - Skin Fragments
    - Transmittable Disease (Tuberculosis/Common Cold/etc.)
21. *Ceiling Plenum*
    - Asbestos & Fiberglass
    - Vermiculite
    - Mold & Bacteria
    - Dust/Debris
22. *Paints/Stains*
    - VOCs
    - Lead (Paint Pre-1978)
    - Contain Preservatives and Fungicides
    - Flaking/Aerosolization

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Fragrances and Odours

95% of the chemicals used in fragrances today are synthetic derived from petroleum

Only about 1,300 of the 5,000 materials for use in fragrances have been tested

884 of 2,983 chemicals used in the fragrance industry capable of causing cancer

58% increase in asthma over the past decade

Benzaldehyde, a chemical known to cause kidney damage is used in fragrances

Benzyl Acetate used in fragrances is linked to a cause of pancreatic cancer

Ethyl Acetate is a known carcinogenic, causing kidney and liver failure and it is used in fragrances

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Element Six
Investigating IAQ Concerns

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6. Investigating IAQ Concerns

i. Investigating complaints
ii. Exploring exposure and health effects
iii. Risk assessments

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Element Six
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Reasons for investigation

Contamination sources

Pollution pathways

HVAC system

Occupants complaints

SYMPTOMS RELATED TO INDOOR AIR POLLUTANTS

	Particles			Bioaerosols				Gases		
	Dust, Soil, Ash...	Tobacco Smoke	Pollen	Molds, Mildew, Fungus	Bacteria, Virus	Pet Dander	Dust Mites	Carbon Monoxide	Formaldehyde	VOCs
Headaches		X	X					X	X	X
Dizziness	X			X		X	X			
Fatigue			X					X		X
Nausea								X	X	
Vomiting									X	
Skin Rash					X					X
Eye Irritation	X	X	X	X	X	X			X	X
Nose Irritation	X	X	X	X	X	X	X		X	X
Throat Irritation	X	X							X	
Respiratory Irritation		X		X	X		X		X	X
Cough	X	X	X	X	X	X	X		X	
Chest Tightness				X	X	X	X		X	
Respiratory Infections	X	X		X	X					X
Asthma (exacerbation of)	X	X	X	X	X	X	X		X	
Allergic Reactions	X		X	X	X	X	X			
Lung Cancer		X								

Activity:

Group Exercise
Design an occupants IAQ questionnaire

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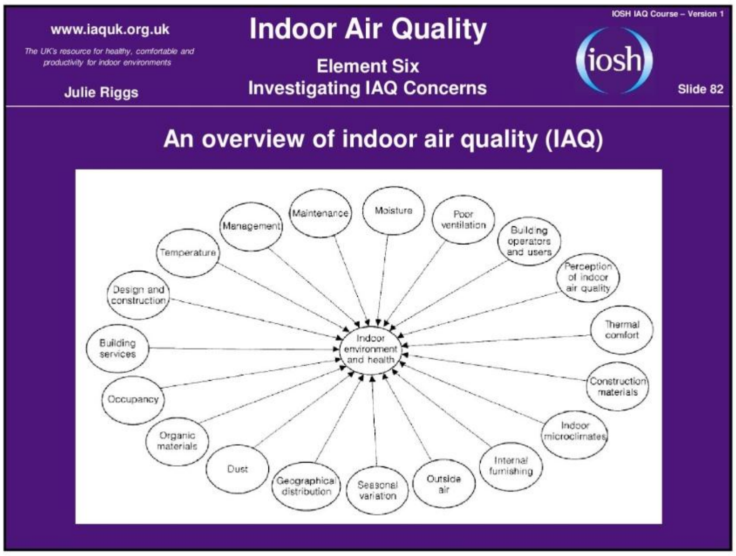
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An overview of indoor air quality (IAQ)
Indoor environment and health
Management
Maintenance
Moisture
Poor ventilation
Building operators and users
Perception of indoor air quality
Thermal comfort
Construction materials
Indoor microclimates
Internal furnishing
Outside air
Seasonal variation
Geographical distribution
Dust
Organic materials
Occupancy
Building services
Design and construction
Temperature


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Identify the risks
Consult with occupants
Conducting monitoring
Identify potential thermal sources
Identify thermal transfer
Assess the risk
Number of people involved
Vulnerability of people
Work practices and work rate
Type of plant, equipment or materials used
The capability, skill, experience and age of people doing the work
Control the risk
Eliminate or control the risks as reasonably practicable using hierarchy of controls
Monitor and review
Monitor and review as required by your risk assessment
Occupants should be consulted when assessing the potential risks from exposure to hot or cold conditions. Employees must also have input into the risk controls selected

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Element Seven

Proactive IAQ Management

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7. Proactive IAQ Management

i. Methodology of sampling

ii. Survey for health risks

Types of instruments for measuring IAQ

iii. EH40 standards

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Methodology of sampling

Define survey objectives
Develop a list of target compounds and parameters
Determine which exposure durations need to be evaluated
Choose a sampling method
Conduct pre-sample survey
Define methodology (location/timings)
Conduct sample
Evaluate sample against quantities limits
Define action/control measure
Evaluate need to resample

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Surveys for Health Risks

Range of equipment can be used:

- Stain tube detectors
- Dust monitoring equipment (inhalable/respiratory)
- Photoionization Detector (PID)
- Passive samplers
- Bag Sampling

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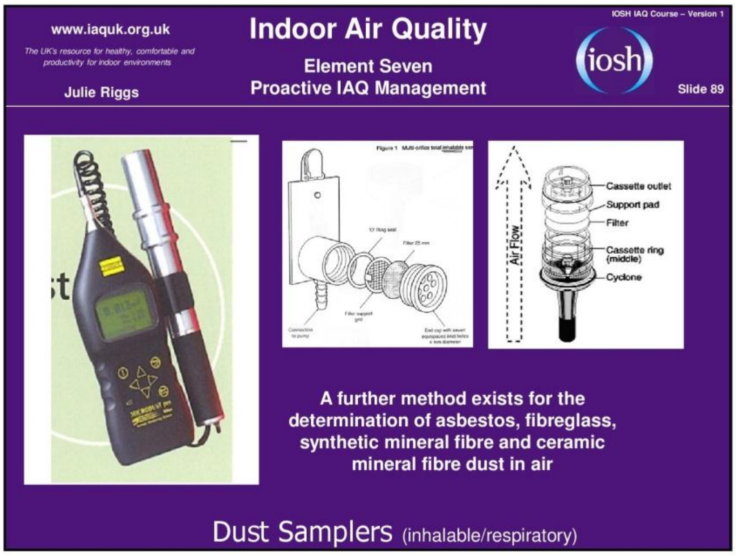
Slide 88
Draeger Detector Pump and Stain Tube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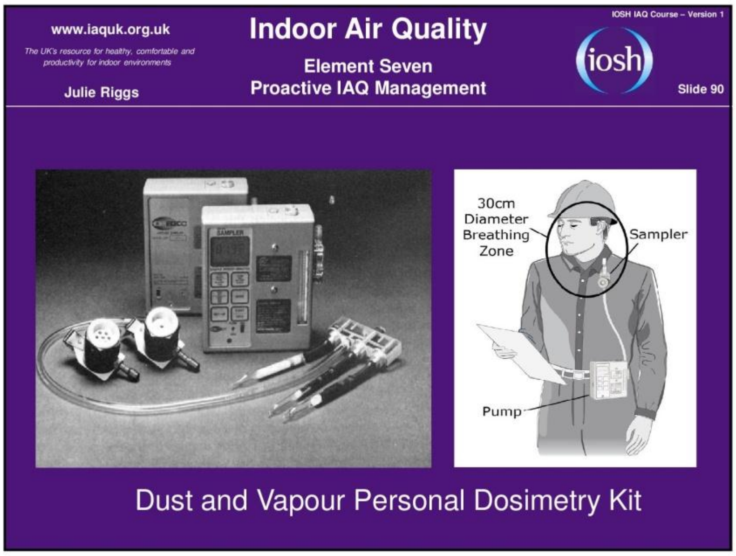
The UK's resource for healthy, comfortable and productivity for indoor environments
Julie Riggs
Indoor Air Quality
Element Seven
Proactive IAQ Management
IOSH IAQ Course – Version 1
iosh
Slide 89
Air Flow
Cassette outlet
Support pad
Filter
Cassette ring (middle)
Cyclone
A further method exists for the determination of asbestos, fibreglass, synthetic mineral fibre and ceramic mineral fibre dust in air
Dust Samplers (inhalable/respiratory)

45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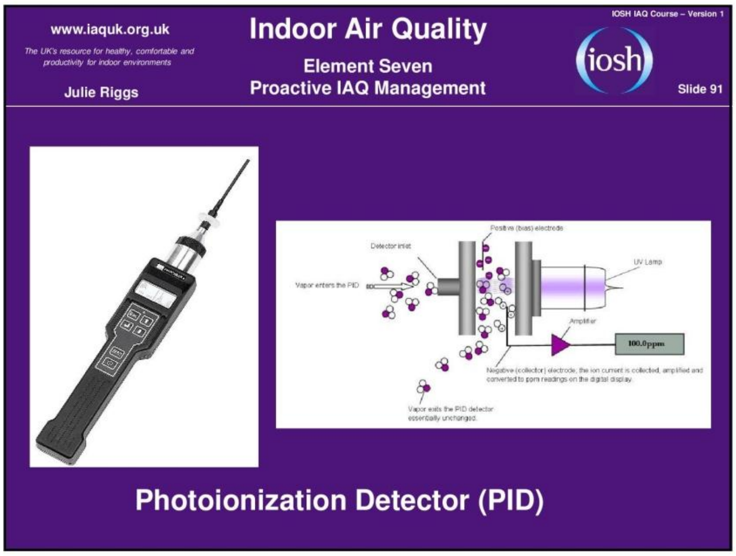
Slide 90
30cm Diameter Breathing Zone
Sampler
Pump
Dust and Vapour Personal Dosimetry Kit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Positive (bias) electrode
Detector inlet
UV Lamp
Vapor enters the PID
Amplifier
100.0ppm
Negative (collector) electrode; the ion current is collected, amplified and converted to ppm readings on the digital display.
Vapor exits the PID detector essentially unchanged.
Photoionization Detector (PID)

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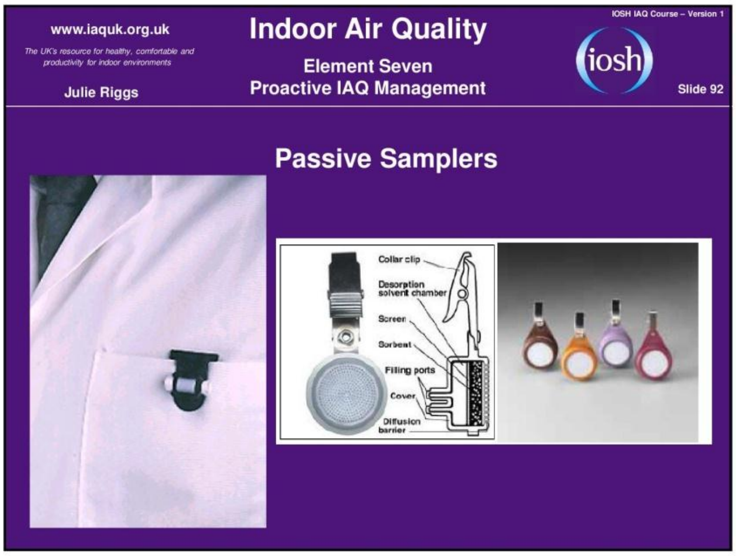
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Passive Samplers
Collar clip
Desorption solvent chamber
Screen
Sorbent
Filling ports
Cover
Diffusion barrier


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Slide 93
Bag Samplers

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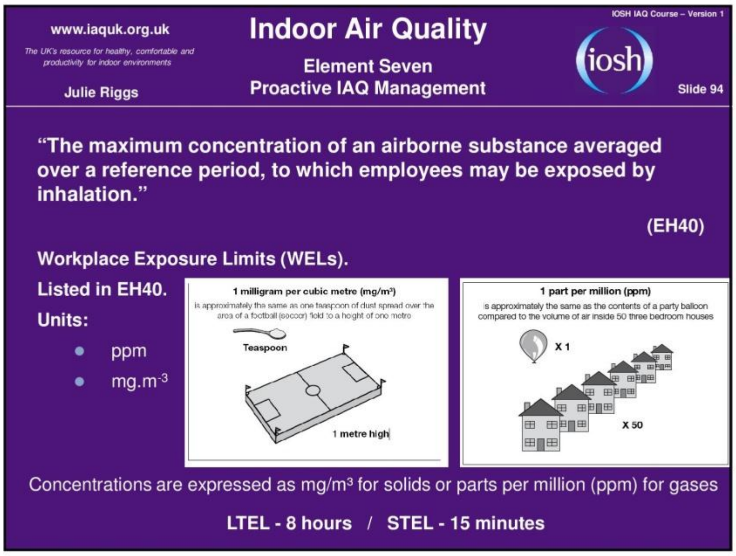
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Slide 94
"The maximum concentration of an airborne substance averaged over a reference period, to which employees may be exposed by inhalation."
(EH40)
Workplace Exposure Limits (WELs).
Listed in EH40.
Units:
ppm
mg.m-3
1 milligram per cubic metre (mg/m³)
is approximately the same as one teaspoon of dust spread over the area of a football (soccer) field to a height of one metre
Teaspoon
1 metre high
1 part per million (ppm)
is approximately the same as the contents of a party balloon compared to the volume of air inside 50 three bedroom houses
X 1
X 50
Concentrations are expressed as mg/m³ for solids or parts per million (ppm) for gases
LTEL - 8 hours / STEL - 15 minutes


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communication
8. Proactive IAQ Management


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Indoor Air Quality
Element Eight
Communication
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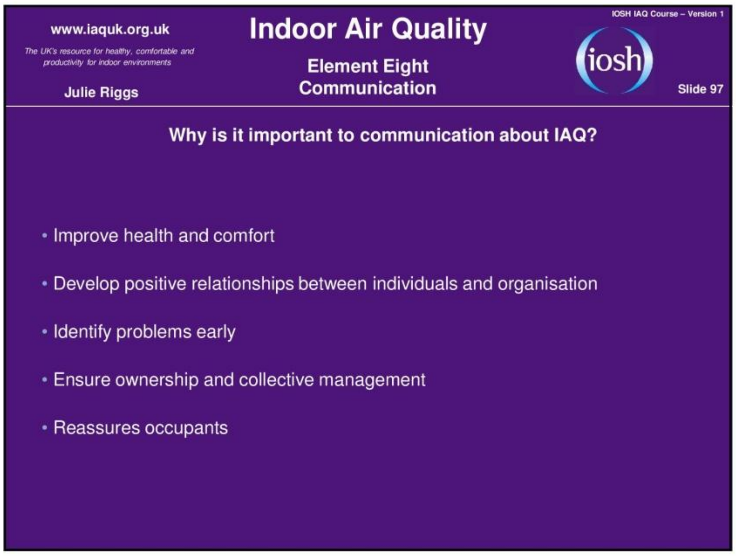
iosh
Slide 96
Contents
8. Communication
i. IAQ Communication
ii. Risk perception
iii. IAQ - the business case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Julie Riggs
Indoor Air Quality
Element Eight
Communication
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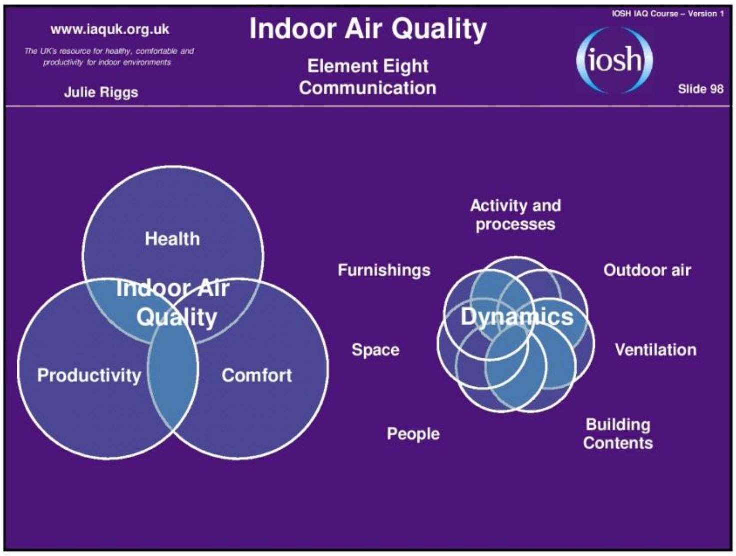
iosh
Slide 97
Why is it important to communication about IAQ?
• Improve health and comfort
• Develop positive relationships between individuals and organisation
• Identify problems early
• Ensure ownership and collective management
• Reassures occupants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Indoor Air Quality
Element Eight
Communication
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Slide 98
Health
Indoor Air Quality
Productivity
Comfort
Activity and processes
Furnishings
Outdoor air
Dynamics
Space
Ventilation
People
Building Contents


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Indoor Air Quality
IOSH IAQ Course – Version 1
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Slide 99
Learning Objectives
• Outline the scope and nature of indoor air quality
• Explain the benefits of good IAQ and the consequences of poor IAQ
• Describe the types and components of ventilation systems
• Outline the process for investigating IAQ complaints
• Identify the sources of contamination and preventive measures to adopt
• Describe techniques and methodology for surveying and monitoring
• Conduct risk assessments of IAQ

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Appendix 15 – IOSH Delegate Feedback Form

IOSH CPD IAQ Certificate

Delegate feedback form

Training provider	
Course location	Course date(s)
Name(s) of your trainer(s)	
Your name	
Your job title	
What made you decide to come on this course?	

We'd like to know how you feel about the course. How do you rate these parts?

	Excellent	Good	Poor	Very poor
Animated presentation				
Overall content				
Delegate workbook				
'Pizza' quiz in Module 1				
Law quiz in Module 4				
Environmental quiz in Module 8				
Risk assessment board game				
'Think what if, not if only' DVD				
'No going back' DVD				
The course overall				

If you've rated any parts as poor or very poor, please tell us why:

What did you think about your trainer(s)?

	Excellent	Good	Poor	Very poor
How well did they present the course?				
Did they make the course interesting?				
How well did they answer your questions?				

If you've rated any of these as poor or very poor, please tell us why:

What did you think of the training facilities?

	Excellent	Good	Poor	Very poor
The training facilities were…..				

Any other comments on the training facilities?

How do you rate the level of the course?

Too difficult ☐ Just right ☐ Too easy ☐

Any other comments on the level of the course?

What did you enjoy most about the course and why?

What did you enjoy least about the course and why?

Would you recommend this course to other people?

Definitely ☐ Probably ☐ Probably not ☐ Definitely not ☐

If you've said probably not or definitely not, please tell us why:

Is there anything else you'd like to tell us about the course?

Thank you for your time!

Appendix 16 – UKIEG Conference details

Dear UKIEG Member A reminder of the call for abstracts (no more than 350 words) oral and poster presentations at the UKIEG annual conference which is taking place on the 4th July 2013, Department of Health, London SE1. Closing date for submission is 15th April 2013. Oral and poster presentations are accepted both in the formal research format (this can be completed work / work in progress / proposals of work, methodology) and also as case studies (as a method to highlight issues / areas where research is required). If you wish for your abstract to be considered for **a special issue of the Journal of the Indoor and Built Environment,** please indicate this on your abstract. **Please see the flyer below, which contains information on topics together with further information on abstract submission.** This conference is open to members and non-members. Information on joining the UKIEG is also provided.

Healthy Indoor Environments: *Latest Evidence and Future Challenges*

Special Issue, ***Indoor and Built Environment*** Selected papers will be offered an opportunity to be considered for a Special Issue of *the Indoor and Built Environment Journal* on zero carbon buildings, health and wellbeing, with a focus on the UK and Europe	A One-Day Conference Organised by the UK Indoor Environments Group www.ukieg.org Date: 4th June 2013 Venue: Department of Health, London SE1 The UKIEG annual meeting is a conference and networking event for a multidisciplinary audience of academics, policy makers and industry experts with an interest in improving indoor environments for health and wellbeing.
This Conference addresses the future challenges and latest research evidence on the factors affecting health and wellbeing in buildings. Topics include: • Impact of zero carbon strategies on health and wellbeing; • Climate Change and overheating impacts on buildings and health; • Latest evidence and good practice on healthy housing; • Neurological effects of indoor pollutants; • Light and lighting. The Conference will include a poster session, networking opportunities and will conclude with a discussion session. The UKIEG AGM will take place during the lunch break.	**Supported by:** the Department of Health and in collaboration with Health Protection Agency (HPA)* *On the 1st April 2013 HPA will become part of Public Health England **Venue Details**: Department of Health, Skipton House, 80 London Road, London SE1 6LH **Further Information**: Isabella.Myers@hpa.org.uk **UKIEG Website**: www.ukieg.org Conference Fee and Registration Details to Follow

Healthy Indoor Environments:

Latest Evidence and Future Challenges

4th June 2013, London

Call for Papers, Deadline: 15th April 2013

If you would like your paper to be considered for an oral presentation or poster at this Conference, please submit an abstract (no more than 350 words): Isabella.Myers@hpa.org.uk by Monday 15th April 2013.

Please indicate with your abstract submission whether you would like your paper to be considered for the Special Issue of the *Indoor and Built Environment Journal*.

Notification of abstracts selected for presentation: 30th Apr 2013

Notification of papers selected for peer-review process of the Special Issue of *Indoor and Built Environment Journal*: 10th June 2013.

Please note, papers invited to submit for the peer-review process of the Special Issue of *Indoor and Built Environment* will be expected to submit a full paper by 2nd September 2013.

Appendix 17 - UKIEG Conference Poster Presentation Abstract

HEALTHY INDOOR ENVIRONMENTS CONFERENCE 2013
POSTER PRESENTATION SUBMISSION

Name of Submitter	Julie Riggs
Title of Abstract	Conceptualising IAQ by bridging an academic and practitioner's application, pioneering the UK's IAQ training and website resources and influencing strategic change via leadership and discussion *Doctorate of Professional Studies (DProf) - in progress* *Middlesex University* • *Academic Supervisor: Professor Hemda Garelick* • *Programme Leader: Dr. Gordon Weller*

This DProf project is intended to understand the contextualised setting and positioning of IAQ within the UK, using my experiences as an internal researcher, working with safety practitioners and Local Authorities, to develop a cohesive body of understanding that contribution to the indoor air quality debate; in particular the transfer of embodied knowledge into contextual practices influencing key stakeholders for future sustainability.

This DProf project discusses the gap between IAQ knowledge and practical application, evaluating historical context, critiquing combined contaminates, reviewing fragrances, appraising competencies, resources and government policy, both UK and Worldwide. To explore risk perception and competencies within a real world situation, two types of surveys were conducted with Environmental Health Officers and health and safety practitioners.

The literature research and project activities raised further discussion points regarding the application of risk management, cost effective modelling, impact of body burden, the increase trend of scent marketing, understanding and influencing society risk perception and evaluation of the leadership of IAQ at local and government levels This project highlights some key recommendations such as the requirement to label products, particularly products like perfume where manufacturers claim brand protection, to enable the consumer to understand the ingredients and make choices about their purchases; Bio-monitoring and multi-pollutant frameworks to build on existing silo contaminate research and create a harmonised and structured approach in understanding psychological and physiological impact interactions from a mixture of pollutants. I further discussed the repositioning of IAQ within a strategy and leadership approach; thus engaging a transformative rather than additive philosophy; As a legacy of the project, the first accredited UK IAQ training certificate and website was developed, implemented and appraised I concluding with my reflection on my own epiphany of learning, how I traversed between academia and a professional application and my contribute towards my profession.

Profile of author:

Julie J Riggs

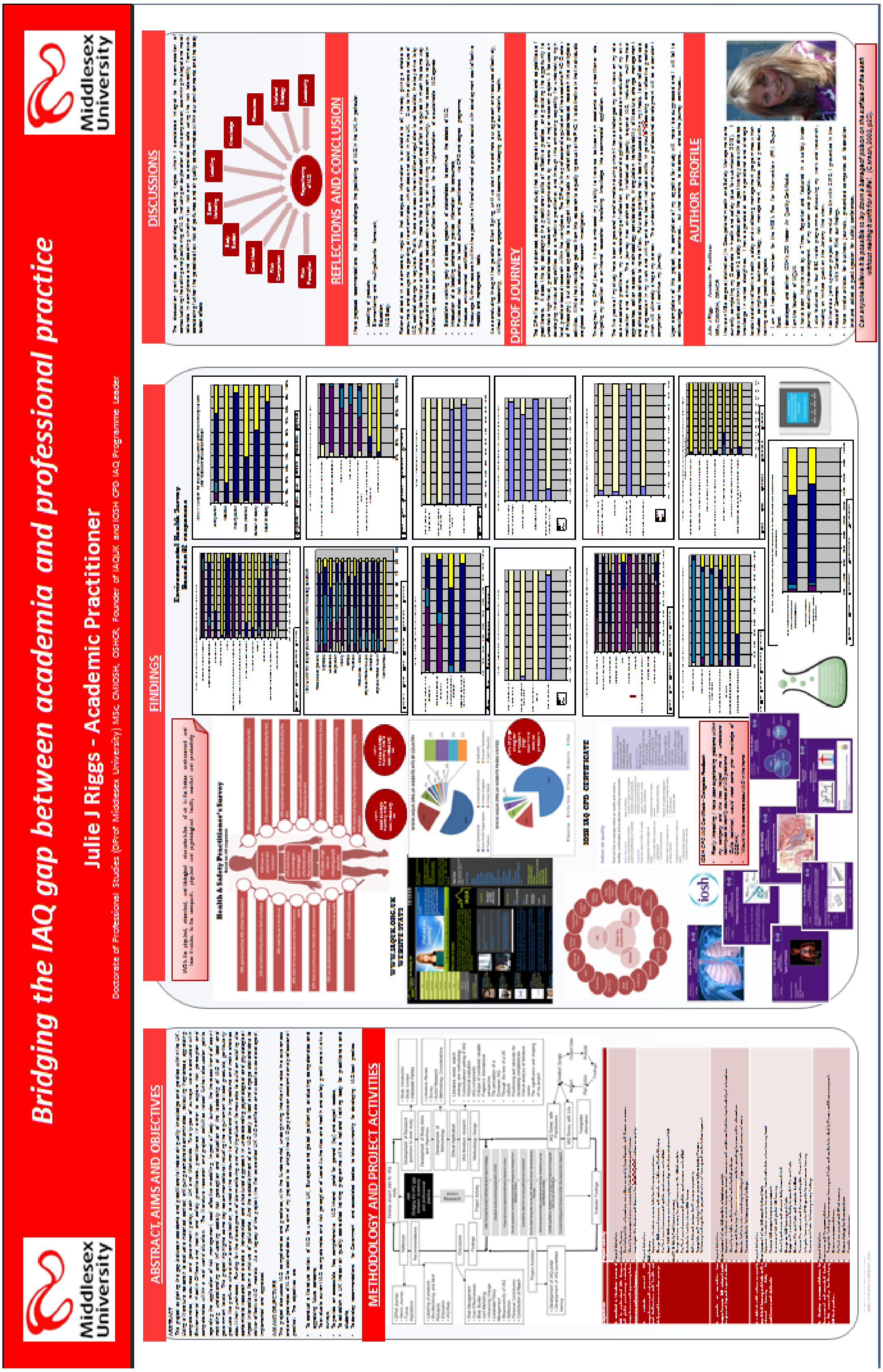
MSc, CMIOSH, OSHCR

I have an MSc degree (distinction) in Occupational Health and Safety Management and currently completing my DProf with Middlesex University.

I have worked within the health and safety profession for the past twenty years with diverse knowledge in varied disciplines. I have operated at both operational and strategic levels to deliver effective health, safety and wellbeing management programmes in the UK and Europe, which includes compliance, business strategy, risk management, policies and procedures.

- I am an Independent member for the HSE's Fee for Intervention (FFI) Dispute Panel.
- I developed and deliver IOSH's CPD Indoor Air Quality Certificate.
- I am the founder of IAQUK.
- I have been interviewed by a Times Reporter and featured in a safety trade journey detailing the development of my career and projects.
- I also featured in four BBC radio programmes discussing my work and research, including an invited guest on the Jeremy Vine show.
- I delivered a joint sponsor project on mental health with CIPD, I presented in the House of Commons with Caroline Flint our findings.
- I have wrote articles for business journals, presented companies at federation level and acted as guest speaker for safety conferences..

Appendix 18 – UKIEG Poster Presentation
Please also see attached CD



Appendix 19 – Middlesex Univeristy - Ethical approval letter

Middlesex University

School of Health and
Social Sciences
Hendon Campus
The Burroughs
Hendon
NW4 4BT

To: Julie Riggs

Date: 27th May 2011

Dear Julie

Re: 776 'Raising the agenda and practitioner's competences of indoor air quality within the UK'
Thank you for the response which adequately answers the ethics committee's queries. On behalf of the committee, I am pleased to give your project its final approval. Please note that the committee must be informed if any changes in the protocol need to be made at any stage.

I wish you all the very best with your project. The committee will be delighted to receive a copy of the final report.

Yours sincerely

Adam Choonara
Chair of the Natural Sciences Ethics sub-Committee

Appendix 20 – Future Aspiration

IOSH IAQ Group

- IOSH have contacted me during this project to engage with their member's networking group to deliver professional technical lectures in IAQ, with the intention of raising the agenda across the health and safety industry.
- IOSH have also requested I implement and chair a IAQ focus group, which enables a collection of data and debates and will ensure the support of the lobbying and PR departments of IOSH.

Higher Education

- I am currently in discussions with two universities regarding the environmental health degree programmes and inclusion of IAQ.
- I intend to contact all universities regarding relevant degree programmes, providing free accessible data for inclusion.

Commercial Intergration

- I am engaged in working with commercial organisations to establish cost effective IAQ models and dimensional case studies to support the rationale of managing IAQ.
- I am also in discussing with pressure groups regarding the use of perfumes and odours in consumer products.

Independent Body

- Speaking with IAQ service providers and environmental groups, they have suggested that an independent IAQ organisation is developed to create a central resource and possibly a body to oversee IAQ. Four IAQ consultants in the UK have offered data of their survey findings. Therefore I intend to continue developing IAQUK as a non-profit organisation/site with the intention of linking with an establish provider such as IOSH to explore this discuss further.

Publishing Work

- I intend to continue my commitment to a publisher to write a practitioner's guide to IAQ book;
- I will continue my work of writing articles for publication, conference speaking and workshops.

Appendix 21 – IOSH IAQ Feedback Letter

imited

LE18 1NN
UK
t +44 (0)116 257 3100
f +44 (0)116 257 3101
www.iosh.co.uk

Mrs Julie Riggs
Flat 4 Brean House
19 Montpelier
Weston-Super-Mare
Avon
BS23 2RJ

Our ref: Course Provider Feedback

19 December 2012

Dear Julie

Re: IOSH Professional Development Training Programme 2012

We refer to the course, which you deliver as part of the IOSH Professional Development Training Programme at The Grange, Wigston, Leicester.

The evaluation Reports and/or Delegate Feedback Forms for the courses in the last quarter have now been received and analysed. We are therefore now in a position to relay the information to you on how your sessions were received.

Title of Course	Dates	% Positive Approval	Comments
IAQ	18/09/12	100%	1. Excellent, really enjoyed. 2. A very interesting course made even better by Julie's delivery style and knowledge. 3. Thank you very much. The course was excellent.

We would be glad to discuss any plans you have for addressing the improvements suggested in the comments. Overall the courses have been favourably received.

On behalf of the IOSH Professional Development Team, I would like to thank you very much.

Kind regards,

Kinga Stasiak
Bookings Support Administrator
kinga.stasiak@iosh.co.uk

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